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# Gender differences in target throwing skills and dart playing performance: Evidence from elite dart players.

Linda Duffy

BSc (Hons) Psychology  
Diploma in Psychology

May 2002

Thesis submitted to Middlesex University as partial  
fulfilment of the requirements for a Doctor in Philosophy in  
Psychology

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"In a crowd all alone, a lonely heart without a home, if this is the end"



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## **Abstract**

A series of experimental and quasi-experimental research were conducted to investigate gender differences and differences across levels of skill amongst elite dart players.

Experiments 1 and 1a employed an identical experimental setting and were designed to investigate gender differences in target throwing accuracy and attitudes towards target throwing among undergraduate students and elite dart players. A further aim was to investigate differences between level of skill for the elite players. Results showed an overall significant superiority for men in target throwing accuracy, moreover, analyses of questionnaire data found significant gender differences in attitudes towards target throwing.

Experiment 2 examined whether gender differences in target throwing accuracy may be eliminated if elite dart players undertook the same target throwing task as in Experiment 1a using their non-preferred hand. The results of Experiment 2 showed that when using their non-preferred hand gender differences in target throwing accuracy were eliminated.

In Study 1 data from the same elite dart players employed in Experiments 1a and 2 were correlated with archival data, in the form of single dart averages, taken from a 'real world' dart playing environment. A strong relationship was found between the two dependent measures for the men's data whereas results for women, although in the same direction, did not reach statistical significance.

Using single dart averages as the dependent measure, Study 2 investigated the extent of gender differences across three levels of skill. Results showed that the extent of gender differences was far-reaching with data from the lowest skill level of men players

being significantly superior to that of the highest skill level for women players. There were also uniformly predictable significant within gender differences for men across levels of skill but, interestingly, this was not the case for women.

Study 3 explored whether physical and experiential factors, namely, height, arm length and career span may have an impact on the significant gender differences found in dart playing performance. Analysis of the data found that even when physical and experiential factors were controlled for there were still significant gender differences in dart playing performance.

By way of an ex-post facto research approach Study 4 employed a semi-structured interview technique, similar to that used by Ericsson, Krampe and Tesch-Romer (1993), the aim of which was to investigate the development of elite dart players representing two levels of skill. The results revealed no significant differences on demographic variables namely, age, starting age and career span. Variables related to particular dart playing activities were also investigated. In brief, results showed evidence to suggest that deliberate practice could account for differences in performance across levels of skill but not for the superiority of men over women.

Implications of these findings and suggestions for follow up research are discussed.

## **Chapter 1: Overview-synopsis**

"If we want to know how fast a human being can run, then it is no use to average out the speed of a "good sample" of the population; it is far better to collect Olympic gold medal winners and see how well they can do." Maslow (1971). Quoted in Ericsson and Charness, (1994).

### **1.1 Background and rationale.**

Over recent decades the study of sex differences in human performance has grown to be of significant interest to psychologists (Maccoby and Jacklin, 1974; Thomas and French, 1985; Feingold, 1993; Eagley, 1995). Thanks to the rise of cognitive psychology during the 1960's much of the initial investigations have focused on gender differences in predominately cognitive skills/tasks, such as mathematical and verbal abilities. The general consensus being that girls are superior to boys in verbal abilities but that boys outperform girls in mathematical skills (Maccoby and Jacklin, 1974). However, moving away from purely cognitive abilities, parallel research has shown that men and women can also be distinguished on their motor skill performance (e.g. Thomas and French, 1985; Thomas and French, 1987; Feingold, 1993). Particularly, from a developmental perspective, males have been shown to outperform females from early childhood to adulthood on several aspects of motor performance, such as catching, kicking, jumping and most relevant to this thesis, throwing (see Thomas and French, 1985 for a review; Thomas and French, 1987; Watson and Kimura, 1989; Watson and Kimura, 1991). One exception to this superiority for males can be found in previous literature on Developmental Co-ordination Disorder where, when investigating clumsy children, a higher prevalence of this disorder has been found in boys



(Sugden and Sugden, 1991; Sims, Henderson, Morton and Hulme, 1996). Suffice to say the focus of this investigation is on 'normal' adults, therefore it is not within the scope of this thesis to discuss the literature on Developmental Co-ordination Disorder.

Indeed, of all motor skills investigated, arguably the largest and most reliable gender differences are those observed in throwing ability, with the differences in favour of males at all stages of development (Thomas and French, 1985; Thomas and French, 1987). A further area of interest is whether or not performance on a task which arguably would depend on accurate throwing, such as dart throwing, is highly predictable on the basis of one's gender (e.g., Thomas and French, 1987). Whilst the literature on gender differences provides universal agreement on observable differences in throwing skills, and related tasks, the reason such differences exist are far from universally agreed. For example, some researchers maintain that biological/genetic factors are influential predictors of throwing skills (Janowsky, Chavez, Bambi, Zamboni, and Orwoll, 1998) while others (McKenzie, Alcaraz, Sallis, Faucette, 1998) argue that environmental factors are the more crucial contributors to gender differences in throwing. Furthermore, work by Watson and Kimura (1991) revealed that although adult men significantly outperformed adult women on a dart throwing task, this advantage was not attributable to differences in physique, athletic experience or intelligence but more likely to be 'related to some type of spatial function' (p. 382).

Whilst there is still uncertainty in the reported literature as to why such significant gender differences exist, it is even more unclear as to what factors, if any, may change this balance? Could women ever overcome their lack of skill in target throwing by say extensive practice? More generally how does one perfect his/her skill in target throwing and is there a difference between men and women in their 'route' to perfection? To find a

solution to these questions one needs to move away from examining throwing skills among a novice population of boys and girls and/or college students and focus more on a population of men and women who have aimed to perfect their throwing skills. This unique population could be found among "elite" dart players; a sporting activity which arguably rests highly on one's skill in target shooting and is therefore the focus of this thesis.

However, returning to the related literature, gaining expertise in a particular sport is now the subject of a growing body of research, pioneered by the work of de Groot (1946/1978) and extended by Charness (1976) on expert chess players. Charness and colleagues were able to provide an indication of how cognitive skills, such as memory and strategies, are needed to perfect the "sport" of chess. However, a more recent focus on the acquisition of expertise has favoured an environmentalist approach. First through the work of Bloom (1985), whose research was based on interview data with elite performers (see chapter 3 for detailed information), and later through the work of Ericsson, Krampe and Tesch-Romer (1993) whose theory implicated "deliberate practice" as a key factor in acquiring music expertise. Their paradigm has now been tested in several sporting activities requiring motor skills (Hodges and Starkes, 1996; Starkes, Deakin, Allard, Hodges, and Hayes, 1996; Helsen, Starkes and Hodges, 1998; Hodge and Deakin, 1998; Starkes, 2000; Van Rossum, 2000). The pioneering work of Ericsson et al., (1993) suggests that men and women could aim at perfection in a given activity by engaging in vast amounts of training i.e., deliberate practice. Ericsson et al.'s (1993) Theory of Deliberate Practice, which was originally derived from two studies with violinists and pianists of varying levels of skill, not only has appeal in a sporting context but also provides the framework for a general theory of expertise applicable to several other domains. Their theory of expertise can be

explained by an information-processing (or skills) approach, whereby expert performance is underpinned by knowledge and skills acquired through deliberate practice. Ericsson et al., (1993) used retrospective reports of the amount and type of practice that each of the musicians engaged in since the start of their careers. From the evidence accrued they suggested that the accumulated number of hours spent in activities designed purely to improve performance (deliberate practice) were a function of skill level for both sets of musicians. Research conducted in several physical sports supports Ericsson et al.'s (1993) claim that experts, when compared to novices, do in fact engage in vast amounts of deliberate practice (e.g. soccer and field hockey, Helsen, et al., (1998), karate, Hodge and Deakin (1998), wrestling, Hodges and Starkes, (1996) and figure skating, Starkes et al., 1996). Thus, based on previous literature, highlighting the development of expertise, a new line of research questions aimed at investigating throwing skills may enter into the equation. Such as; would the same degree of male superiority be observed among an elite population of men and women who have made a premeditated attempt at perfecting their throwing skills? If so, what is the extent of such differences? Moreover, are there additional factors that may contribute either by bridging the gap between men and women or by enhancing the superiority of men in some way.

Arguably, the ideal population for investigating such research questions are elite dart players who engage in a sporting activity which to a large extent depends on one's ability to perfect skills in throwing for accuracy, (henceforth referred to as target throwing). Thus, investigating issues such as the role of deliberate practice and its impact on dart performance would be of particular interest to both research on gender differences in target throwing and on the development of expertise in dart playing. Arguably thus far, careful reading of the reported literature on the development of expertise, particularly in a complex

sporting environment, has not clearly revealed the possible independent contributions of such variables as practice, as opposed to cognitive factors such as strategies, which are known to have an effect on performance; (see Charness,1989). The distinction between the two will be argued later to be less of a problem in relation to dart playing. Thus it is argued here that perhaps, by targeting elite dart players as participants and by assessing their performance in laboratory based tasks as well as the 'competitive' arena, evidence may be uncovered regarding the extent and reasons for gender differences in throwing skills and dart playing performance. Furthermore, one can investigate factors that contribute not only to gender specific performance but also those relevant to various levels of skill within a particular gender.

Laboratory based research examining purely target throwing ability among men and women dart players of various levels of skill should help to examine the extent of gender differences in throwing. Analysis of an alternative set of data, namely 'single dart averages' accumulated by professional bodies from within the sport of darts should also demonstrate the extent of gender differences in a "real world" dart playing environment. The single dart average is a measure of performance used extensively in the sport of darts. In brief, it is calculated by dividing the number of points required to complete the leg (this is 501 points for championship matches) by the number of darts used to finish the leg. It will be explained that a player's dart playing performance has a direct relationship with their single dart average (for more detail on the single dart average see section 3.8). For example; when comparing the single dart average of two players the player with the higher average has actually performed better than the player with a lower average. Therefore, due to the nature of this scoring system, one is able to reliably assume that superior players will always record a higher single dart average. Indeed single dart averages are used by the world

governing body in the sport of darts as selection criteria for invitational competitions and for the classification of players as International/professional, intermediate/county and superleague/local level of skill. Most important is the nature of any relationship between data from laboratory based throwing tasks and single dart averages taken from the "real world" dart playing environment. Should factors contributing to dart playing performance rely heavily on one's target throwing skills, then a strong relationship between the two should exist. If, on the other hand, there is not a strong relationship one may seek alternative variables that may contribute to expertise, such as possible strategic factors in actual game performance. A further issue to note is that whilst, for practical reasons it is difficult, if not impossible, to systematically engage elite dart players in various experimental settings in order to examine their skills under controlled conditions, an alternative method would be to make reference to a vast amount of bona fide data in the form of single dart averages. Such data could then be used to tackle research questions of various theoretical interests. As explained previously, should a strong relationship exists between target throwing accuracy and single dart averages it implies that; i) actual performance in a 'real world' competitive darts event is heavily reliant on one's target throwing skills and ii) one's single dart average could also be a strong predictor of one's target throwing skills. However, irrespective of this relationship, one may acknowledge there is still a need to highlight the possible contribution of alternative factors, namely strategies (for example Charness, 1976) and/or factors such as anxiety, induced by the external environment (for example Meyers, Bourgeois, LeUnes and Murray 1999) and their influence on single dart averages and game performance. These are additional issues that will either be addressed in this thesis or suggested for future research.

Returning to the single dart average and data from laboratory based target throwing, the key question remains as to which factors may have contributed to the possible difference between elite men and women and between levels of expertise. To investigate this principle aim, a modified version of the semi-structured interview schedule employed by Ericsson, et al., (1993) when proposing their 'Theory of Deliberate Practice' was used. Briefly, the semi-structured interview schedule (see appendix 6 for a copy of the interview schedule) incorporates 88 questions in 7 sections plus an Activity Chart. The 7 sections include 1) general biographical, 2) darts biography, 3) specific practice, 4) general practice, 5) the role of practice in maintaining level of performance, 6) performance career and 7) memory and performance problems. The findings are reported in Chapter 6 of this thesis with the exception of section 7 (memory and performance problems) where a ceiling effect was found, i.e., all participants claimed to have memorised 100% of dart finishes (see section 3.8 for an explanation of dart finishes). The activity chart is designed to enable each participant to record the weekly number of hours spent engaging in those activities most relevant to dart playing performance (see appendix 7 for a copy of the activity chart ). This interview schedule, as mentioned previously, has been used in a number of previous studies aimed to examine factors contributing to the acquisition of expertise among sporting performers.

## 1.2 Aims.

Thus in brief, the main aims of this thesis are to engage in a pioneering attempt to examine the extent of gender differences among men and women elite dart players, of various levels of skill, both in the form of laboratory based experimental data and data in the form of single dart averages. Moreover, by using semi-structured interviews one is able to explore possible contributing factors to dart playing performance and target throwing skills.

These aims are achieved in a series of experimental and quasi experimental questionnaire based data as reported below:

- i) to examine the extent of gender difference among a sample of university students and elite dart players in their target throwing skills under controlled laboratory conditions (Experiments 1, 1a and 2 reported in chapter 4).
- ii) to examine the relationship between laboratory based target throwing skills and data from a 'real world' dart playing environment in the form of single dart averages (Study 1 reported in chapter 5).
- iii) to examine the extent of gender differences, using the single dart average as the dependent measure, across three levels of skill namely, International/professional, intermediate/county and superleague/local (Study 2 reported in chapter 5).
- iv) to examine whether purely physical factors such as height and arm length and experiential factors have a significant impact on target throwing skills and single dart averages (Study 3 reported in chapter 5).
- v) to examine data collected via semi-structured interviews in order to investigate possible contributing factors to target throwing skills and to the acquisition of dart playing expertise. Moreover, to examine the relationship of interview data with

single dart averages and target throwing accuracy data collected via laboratory controlled experiments (Study 4 reported in chapter 6).

### **1.3 Summary chapters.**

The aim of Chapter 2 of this thesis is a review of the literature investigating age and gender-related research on the development of throwing abilities. The focus is predominately on novice-naïve participants of various age groups. The ultimate conclusion is of a general consensus favouring a constant and predictable pattern of development from early childhood to adulthood with male superiority significantly evident at all these stages. Moreover, there are indications that practice, at least in a laboratory setting and targeted at naïve participants, does not upset this balance. Also noticeable in the literature review in chapter 2 is the debatable issue as to whether environmental or genetically related factors are responsible for age and gender related differences in target throwing.

The literature review provided in Chapter 3 sees a shift to the research on elite populations and, hence, a search for factors that may contribute to ones quest for perfection in his/her chosen activity. Here a review of the “historical” literature shows that early research noticeably focuses on the acquisition of expertise in cognitive tasks with more recent work aimed at investigating the role of deliberate practice in perfecting tasks involving physical and motor skills.

Particular attention will be afforded to the work of K. Anders Ericsson, at Florida State University, and his colleagues, as they are the prime architects responsible for the extensive research into the role of deliberate practice as a contributory factor of elite



performance. The general consensus emerging from much of the aforementioned research appears to be that one needs to establish a clearer picture of factors contributing to expert performance. In particular there is a need to make clear distinctions between purely cognitive skills and purely motor skills. The sport of darts, as will be argued in Chapter 3, provides an ideal medium for this investigation.

Phase one of the data collection and analysis reported in three Experiments and three Studies, is aimed at examining the extent of gender differences and levels of skill in target throwing and dart playing ability. Phase two of the data collection and analyses focuses on a final Study to explore possible factors that may contribute to such differences.

The aim of Experiment 1 ( $n = 40$ ) is to investigate gender differences in target throwing amongst a naïve population and to evaluate methods used in a laboratory setting. Experiment 1a ( $n = 48$ ) is aimed at investigating the extent of gender differences in target throwing accuracy amongst elite dart players representing two levels of skill namely; Intermediate/county level and International/professional level. The predictions were that men would generally outperform women in target throwing accuracy and there would be a significant within group effect due to level of skill with International/professional level players outperforming Intermediate/county level players. However, it was not clear as to whether there might also be a significant interaction effect. Specifically, would International/professional women score significantly better than intermediate/county men? In addition to engaging in target throwing tasks participants in Experiments 1 and 1a completed a short questionnaire providing demographic information and task-related opinions (see appendix 1 for a copy of the questionnaire for naïve participants and appendix 2 for a copy of the questionnaire for elite participants). The results from both

experiments confirmed the main effect predictions i.e., a significant male superiority in target throwing. Moreover, in the case of International/professional level players, men were superior even though their female counterparts were aspiring to perform at a comparable level and had intentionally sought to perfect their target throwing skill. Furthermore, the unpredicted finding in Experiment 1a that intermediate/county level men performed significantly better than International/professional level women merits particular attention as it highlights even greater support for male superiority even when women are ranked at the highest level of their professional performance. Whether or not such differences may be eliminated when elite participants use their non-preferred hand to throw was viewed worthy of investigation. Therefore, in Experiment 2 elite participants ( $n = 48$ ) were asked to throw under the same conditions as in Experiment 1a with their non-preferred hand. Contrary to previous research findings on college students (see Watson and Kimura, 1989) the results showed no significant main effects for gender or level of skill and no significant interaction when elite participants were instructed to complete the same task as in Experiment 1a using their non-preferred hand. This suggests that perhaps there are no fundamental gender differences precluding women to perform as accurately as men.

The question pursued in Study 1 was whether parallel results would be found if the measure of performance was single dart averages recorded in a "real world" dart playing environment. As explained in Chapter 3, single dart averages are a pure measure of dart throwing performance, incorporating all aspects of dart playing skill, independent of wins and losses. Thus, whether men at all levels of elitism still outperform their female counterparts when using the single dart average as a measure of performance has important implications.

In Study 1 single dart averages from the same population that took part in Experiment 1a were analysed and correlated with the target throwing scores also reported in Experiment 1a. The results showed a significant relationship between target throwing scores and single dart averages for International/professional level men and Intermediate/county level men but analyses of the women's data revealed correlations that did not reach significance. These sizeable correlation's indicated that a); the essence of expertise in the sport of darts rests on how accurate one is in target throwing, and b); single dart averages can also be taken as a reliable measure of performance, not only for an investigation of the sport of darts but also in target throwing research.

However, two issues are worthy of further attention. First, would the extent of male superiority be demonstrated in a larger population that also incorporated data from superleague/local (a lower level of skill than either International/professional or intermediate/county) men and women? The second issue is; arguably height and arm length, along with length of playing career, could be viewed as obvious physical and experiential factors that may affect dart playing performance. With this in mind, would the same male superiority be observed if such physical factors were controlled for?

The first issue was tackled in Study 2 where the data of 36 men and 36 women representing three levels of skill namely, International/professional, intermediate/county and superleague/local was analysed. The results showed that men were superior to women at all levels of skill, moreover, men at the lowest level of skill (superleague/local) were still significantly superior to women at the highest level of skill, i.e., International/professional.

The second issue, regarding physical and experiential factors was the subject of investigation in Study 3 where the data of intermediate/county level men and women ( $n = 80$ ) was analysed. The data from Study 2 generally showed that neither arm length, height nor length of playing career were significant factors affecting performance as measured by single dart averages as, even when controlling for these variables, men were still significantly superior to women.

In view of such demonstrated significant effects the aim of phase 2 of this thesis was to investigate factors that may contribute to between gender differences and within gender differences in level of skill employing a modified version of Ericsson et al.'s (1993) semi-structured interview schedule. Evidence gathered from interviews and retrospective reports of 24 men and 12 women elite dart players regarding their developmental histories, current levels of performance and evaluations of practice were analysed and reported in Study 4. Results revealed tentative support for the predictions made by Ericsson et al., (1993) in their theory of deliberate practice (highlighted in chapter 6). In brief, demographic data, namely, age, starting age and career span was not found to effect the significant differences revealed in the performance of men and women. A further section of the semi-structured interview schedule required participants to rate practice on relevance for improving dart playing performance on four separate dimensions using a scale of 0 - 10, where 0 was low, 5 was average and 10 was high. Again, there were no significant differences between gender or level of skill on these ratings with the most salient finding being that all participants regardless of gender and level of skill rated practice as highly relevant for improving dart playing performance. Several dart playing activities were investigated, namely, playing league darts, playing in competitions and playing darts with friends for fun, the results of which are reported in chapter 6, along with two types of deliberate

practice, solitary practice and practice with a partner. There was evidence to suggest that the accumulated number of hours of solitary deliberate practice and total deliberate practice (that is the amount of solitary deliberate practice and practice with a partner combined) is a contributing factor in the acquisition of expertise. However, when investigating levels of performance between genders the effect of deliberate practice is less conclusive. The overall findings of the research reported in this thesis are discussed, with suggestions for follow up research, in Chapter 7.

## **Chapter 2: Development of motor skill and throwing.**

### **2.1 Definition: What is motor skill?**

A motor skill is often described as "a skill where the primary determinant of success is the movement component itself" (Schmidt, 1991. p.8). A common distinction in the motor skill literature, based on the type of environment in which skills are performed, highlights the differences between 'closed' and 'open' skills (Allard and Starkes, 1991). Closed skills are defined as skills that are performed in a consistent, typically stationary environment, an example of such skills in a sporting context would include gymnastics routines, tenpin bowling and dart throwing. Noticeably, competitors who engage in a sport or activity that requires the execution of closed skills would typically take turns with an opponent.

In contrast, open skills are typically performed in a moving, dynamic environment. Many open skills are exercised with an opponent present in the environment throughout competition, in fact, often the opponent is the single most important aspect of the environment; an example of this would include passing and/or running with the ball in Soccer and Rugby. In contrast to those sports and activities requiring closed skills, open skills are generally interactive in nature, in direct contest with an opponent.

Another distinction involves the role of a particular motor pattern. For closed skills motor patterns are the skills; it is critical that the performer be able to reproduce consistently and reliably a defined, standard movement pattern. Closed skills place great technical demands on the performer, 'virtually anyone can throw a dart at a target with some chance of success, but the need to hit the 'triple 20' consistently restricts the careers of many' (Allard and Starkes. 1991). For open skills one needs to be able to reproduce a greater repertoire of motor patterns, but, arguably, there is more room for error while executing the skill, which can still result in a favourable outcome.

The classification of movement patterns into open and closed skills is designed to mark the end points of a movement spectrum with certain skills lying between having varying degrees of environmental predictability and variability. In other words it highlights critical features for skills by defining the performers need to respond to movement-to-movement variations in the environment. By its nature this classification incorporates the processes associated with perception, anticipation, pattern recognition and decision making so the movement can be adjusted to environmental demands. The speed at which these various processes need to be performed is influenced solely by the environment in which the movement is to be executed. For movement patterns classified as closed skills, where the performer can evaluate environmental demands, organise the movement in advance and carry it out without having to make rapid modifications while the movement unfolds, these processes are minimised.

A further distinction in the classification of skills is made between discrete, continuous and serial skills. This classification is based upon the extent to which the movement is an ongoing stream of behaviour as opposed to a brief, well-defined action. If viewed as a continuum, at one end would be discrete skills which incorporate a clearly defined start and finish, often characterised by a movement of brief duration; for example throwing or kicking skills, shooting a rifle or catching a pass in netball. By their nature discrete skills are particularly important for sport performance when considering the infinite number of throwing, catching, kicking and hitting skills manifest in sporting activities. At the opposite end of the continuum would be continuous skills which do not have a clearly defined start or finish and are characterised by movement behaviour that is continuous in nature, displaying skills that flow on for several minutes; for example, swimming, running, skiing or cycling. Lying between discrete and continuous skills at a mid-point on the

continuum would be serial skills. These are defined by discrete actions linked together; for example a gymnastics or figure skating routine. (For an extensive taxonomy of motor skills see, Schmidt, 1991).

### **2.1.1 Definition: What is throwing?**

Throwing is categorised as a ballistic skill, where an individual applies force to an object in order to project it, usually, away from their body (Haywood and Getchell, 1993). Throwing comes in many forms i.e., underarm, sidearm and/or overarm, any of which can be executed with one or two hands, moreover, the type of throw to be performed is mostly determined by task constraints and can require either strength when throwing for distance, speed when throwing for velocity or precision when throwing for accuracy, or indeed any combination of these. Whilst previous researchers have studied all aspects of throwing much of the literature has focused on overarm throwing, from a developmental perspective, using the end product or result of the throwing movement to assess proficiency, (see sections 2.2, 2.2.1, 2.2.2 and 2.2.3. for a literature review).

In sport the throw most often studied by researchers is the one-handed overarm throw (Haywood and Getchell pg. 146. 1993), this is also the type of throw most closely associated with the particular movement performed when throwing a dart (see section 2.1.2 for a detailed description). Therefore, for the purpose of this thesis the key focus is on overarm throwing: more specifically throwing for the purpose of hitting a target. In this respect questions may be asked such as, how does the skill of throwing develop; are there gender differences in the development and execution of accurate throwing and what factors contribute to the efficient functioning of throwing. Previous research aimed at addressing these issues are reviewed in



the remainder of this Chapter, but first section 2.1.2 will provide a brief description of the dart throw.

### **2.1.2 Dart throwing for accuracy: a unique action.**

Working within the motor skill taxonomy outlined in section 2.1 dart throwing fits the criteria of a closed skills sport whereby the environment in which it is played is static and invariable. It would also be classified as requiring discrete skills as the dart throwing action incorporates a clearly defined start and finish characterised by a movement of brief duration.

The type of throw used for dart playing is, in many ways, similar to the very basic throw used by young children during the early stages of their development, (see Haywood and Getchell, 1993, pg. 147), whereby it is restricted to arm action alone, without stepping into the throw and very little trunk action. The upper arm is positioned with elbow up and the throw is executed via elbow extension alone. Children who throw in this manner are said to demonstrate minimal throwing skill. According to Watson and Kimura (1991) movements made to execute a dart throw are 'almost entirely limited to the distal joints of the arm (fingers, wrist, elbow) and to a smaller extent the shoulder (pg.381).

## **2.2 How does the skill of throwing develop?**

If one were to investigate this particular motor skill from a developmental perspective it would be apparent that throwing ability is a fundamental human skill performed by children during the early stages of their development. For example, babies as young as 5 months are able to pick up objects and propel them away from their bodies in what has often been described as a crude throwing action (Marques-Bruna and Grimshaw, 1997).

Researchers have followed children through sequential stages of maturation, from early childhood, through adolescence and eventually into adulthood and on to old age. The general consensus being that throwing ability develops at different rates according to age and gender and is argued to be dependent upon many factors such as, biological, environmental and practice (See Thomas and French; 1985; Thomas and French, 1987, for a review).

In most of the research on throwing thus far, researchers have tended to examine the end product, or end result, of the throwing movement to assess proficiency. This has been achieved in the main by focusing on the measurement of three facets of throwing, namely, distance, velocity and accuracy. Of these three the most relevant to this thesis is overarm throwing for accuracy, as the main focus here is to examine data from participants who employ overarm throwing for accuracy but under conditions where the throwing distance is static and invariable.

### **2.2.1 Age and development of throwing.**

The youngest age targeted by most researchers investigating throwing abilities is around 3 years of age. Prior to this age throwing is mostly an aimless activity for children whereas at around this stage of development it becomes more focused. Systematic research on age related factors in throwing ability dates back many decades. In the late 1950's Humphries and Shephard (1955) found that when comparing children aged 4 - 10 years on several complex motor tasks age was positively correlated to performance. Keogh (1965) examined 1171 children from nursery school age to sixth grade on a number of different motor tasks and found a linear relationship between age related changes and performance. A later study by Schulman, Buist, Kaspar, Child and Fackler (1969) examining 375 children aged between 3 and 8 years

on skills requiring speed of movement also found age to be the most influential variable on performance scores. Morris, Williams, Atwater and Wilmore (1982) examined the relationship between age and motor performance of 269 children between the ages of 3 and 6 on a host of motor performance tests of balance, scramble, catching, speed, run, standing long jump, tennis ball throw, and softball throw. Generally age was found to have a direct and positive relationship with motor performance. Butterfield and Loovis, (1993) examined development of throwing by 381 boys and 338 girls aged 4-14 years. Participants were individually assessed in throwing development and static and dynamic balance. Here again there were indications of a positive and linear development of throwing ability with increasing age. However, interesting to note is the study by Williams, Haywood, and VanSant, (1991) who examined changes in a maximal skill using the overarm throw for force, in male and female active, older adults (aged 63-78 years). Ten women and three men were filmed for 2 consecutive years as they threw tennis balls. Participants threw using patterns and velocities generally observed in children of middle elementary-school years. Williams et al., (1991) reported there was a decline in this force production skill, furthermore, some older adults regressed in the movement patterns they used over a 1-year period. Such findings thus suggest that age is a significant factor in the development of throwing skills with the effects more positive and linear at childhood and adulthood, but with perhaps a decline in older age. These findings have also opened the door for questions such as whether there are *critical stages* in the development of throwing skills and if so, would factors such as an enriched environment especially related to practice, training and/or instructions contribute to its development? This issue is dealt with in the next section.

### **2.2.2 Is there a critical age in the development of throwing skills.**

It has long been recognised that there are critical learning periods in the acquisition of skilled behaviour. Critical learning periods suggest there is an optimal time during which an individual's behaviour responses can be developed to their full potential. A well cited study by McGraw (1935) provides the line of thinking of her contemporaries. Her research examined twin boys; Johnny was the experimental subject who was provided, very early in life, with the opportunity to experience numerous gross motor experiences such as creeping up an incline, swimming and roller-skating. His initial training in these activities began in the latter part of his first month of life. The second twin, Jimmy, served as a control receiving his practice and instruction for the same activities, but in a condensed version and much later at 22 months old. McGraw concluded from the research findings that phylectic activities are under infracortical control and are mainly inflexible to modification during postnatal development. In other words skills such as sitting, crawling and walking are controlled by innate developmental forces and are enhanced by special training. But, in contrast, ontogenetic activities i.e., those more recently acquired in man's cultural evolution, are more susceptible to training, but only within the parameters of the child's level of maturity. McGraw's study highlights the importance of the timing of instruction and implies that children could benefit from an early introduction to many skills and that introducing other skills could be delayed without causing decrement.

Similar studies during the same period such as those by Ketterlinus, (1931); Hilgard, (1932) and Gesell and Thompson, (1941) have shown that maturation is the most significant factor in skill acquisition during early childhood. So much so, that the time required to master a particular skill can be significantly reduced if exposure to, and practice in, that skill is withheld until the child is mature enough to benefit. Gutteridge (1939) found that when almost 2000 children between the ages of 4 - 6 years were tested on a battery of motor tasks such as

jumping, tricycling, hopping, ball throwing, skipping and ball catching, maturation was an important factor in determining proficiency. Furthermore, research by Bloom (1964) suggested that a number of significant human abilities develop rapidly in the first 5 years of life, the implications being that pre-school and the subsequent early years of childhood are highly important in the development of learning patterns and general achievement. However, whilst the significance of the first five years of life are highlighted in earlier research, more recent research tends to make reference to the classification of age related stages in motor skills, including throwing abilities, at two distinctive stages namely, middle childhood (5 - 11 years of age) and adolescence (12 - 18 years of age). The general consensus being that during pre-school years motor development occurs at an accelerated pace with the type of motor skill the child is able to master involving greater perception and cognition. With advancing years performing skills and problem solving becomes more a matter of transfer and less a situation of new learning, with maturation emerging as a significant factor in determining levels of performance (Goodgold-Edwards, 1984). Glassow and Kruse (1960) administered a battery of tests to girls aged 6 - 14 years aimed at investigating performance in tasks such as running, jumping and throwing. They found that 'early development of motor co-ordination is essential for later success or that an inherent nature of motor ability may determine the limit of achievement during the growing years'. In the tasks measured, performance generally improved with age. Singer (1974) tested third and sixth grade boys and girls in a laboratory situation on several different motor tasks and found that sixth graders were generally superior to third graders. Whilst these studies suggest that the distinction between these two age categories may have appeal in showing how skills develop, the distinction has nevertheless shown some unusual patterns. For example; Clark, (1967) found that exceptional primary school athletes were not necessarily exceptional secondary school athletes and vice versa. Moreover, Fowler (1962) has questioned the assumption that skills are necessarily acquired

through the course of maturation and in definitive sequences that correspond to individual stages of development. Whereby much of the early research suggests that maturation is a more important factor than experience in the development and perfecting of skills, Fowler (1962) argues that the timing of training is more effective, particularly if not given too early. Furthermore, optimal timing may, and almost certainly will vary among individuals. In view of such findings one needs to consider the literature regarding issues of whether there *is* evidence of optimal timing for intervention and whether or not some of the maturational evidence reported here is the consequence of an “enriched environment”.

### **2.2.3 Gender and development of throwing.**

There is now a vast body of literature with an almost universal agreement that boys and men are superior to girls and women in most aspects of motor skills, most notably throwing skills (See Thomas and French, 1985; Thomas and French, 1987 for a review). Pioneering works in this area are perhaps viewed as those conducted in the 1950's and 60's. For example; Seils (1951) investigated athletic performance in boys and girls via tasks such as running, throwing, balancing, striking, catching and jumping. The findings revealed greater proficiency with increasing age through primary school years. Sex differences in similar studies have also been reported in favour of boys in the 7 - 9 years age group for ball-rolling skills (Witte, 1962). Dohrmann (1964) found that 8 year old boys were superior to girls in throwing and kicking skills. Furthermore, according to Smith (1956), in the 6 - 9 year age group, boys also learn the skills important to ball throwing accuracy and in a novel ball-bounce test faster than girls. There is further evidence to suggest that age changes in motor performance among girls in middle childhood is relatively stable. For example, as mentioned previously, Glassow and Kruse (1960) administered a battery of tests to girls aged 6 - 14 years aimed at investigating

performance in tasks such as running, jumping and throwing and found that there was a tendency for girls to remain in the same relative position, within the group, throughout development. Keogh (1965), as mentioned previously, examined 1171 children from nursery school age to sixth grade on a number of different motor tasks and found that age related changes in performance for most tasks was linear. Girls were more proficient at hopping while boys were better at throwing. In a further study (Keogh, 1969) examined 5 - 7 year old children in tasks that required limb and body control. Improvement with age was found but interestingly girls out-performed boys on all tasks at each age. It may be concluded from this early literature that boys display greater learning proficiency, therefore higher performance levels than girls in gross motor activities during childhood, with differences becoming more pronounced with increasing age on particular tasks. Although in simple, fine motor tasks, girls usually out-perform boys. Broverman, Klaiber and Kobayashi (1968) argued that ...'evidence exists that females exceed males in tasks that require rapid, skilful, repetition, articulation, or co-ordination of "lightweight ," over-learned responses (perceptual responses, small muscle movements, simple perceptual-motor co-ordination'. p.25). Singer (1974) tested third and sixth grade boys and girls in a laboratory situation on several different motor tasks. He found that sixth graders were generally superior to third graders and boys were superior (although not significantly) to girls on tasks such as stabilometer balance, discrimination reaction time, the Figure Reproduction Test and pursuit rotor tracking.

Two decades of research from the 1980's to the present day appears to further reinforce earlier research findings showing superiority for boys over girls in several tasks. Morris, et al., (1982) examined the relationship of age and sex to the performance of 3, 4, 5 and 6-yr-olds on 7 motor performance test items. 269 children completed tests of balance, scramble, catching, speed run, standing long jump, tennis ball throw, and softball throw. Although

significant age and sex differences were found on most tests, generally age was more related to performance than gender, apart from on tests of throwing and balancing where gender was as important as age in its relationship to performance. Boys were superior to girls at all ages on the throwing tests; girls were superior to boys at age 6 on the balance test. Gender differences of a lesser magnitude were found on the speed run and standing long jump tests with the performance of boys generally being superior to that of girls. For the balance test 3 and 4yr old boys performed similarly as did 5 and 6 year old boys whereas for girls, there were more significant differences from year to year in performance, with the data generally indicating at least 3 distinct skill groups from ages 3 to 6 years. Thus, it appears that gender differences in motor performance occur as early as the pre-school years.

In a longitudinal study Halverson, Robertson, and Langendorfer (1982) examined children, using video footage, from kindergarten through to 2nd grade as they performed 10 trials of the forceful overarm throw. The same subjects were re-filmed in the 7th grade. The horizontal ball velocities of the 22 boys and the 17 girls were compared with predictions made when the subjects were in 2nd grade. The original estimate of an annual rate of change of 5-8 feet/sec/year remained accurate for the boys; the original estimate for the girls had to be increased to 2-4.5 feet/sec/yr. While the gap between the sexes increased throughout elementary school, it increased at a slower rate from 2nd to 7th grade than it had during the primary years. By 7th grade, the girls were 5 developmental years behind the boys. Interestingly, self-reports suggested that boys had participated in more overarm throwing activities than girls.



Hoffman, Imwold and Koller (1983) analysed the throwing and prediction performances of 20 1st, 3rd, and 5th-grade boys and girls within the framework of a 4-part taxonomy originally proposed by Fitts (1966). Throwing performance was assessed under task conditions that varied the motion states of the thrower's body and the target (stationary or moving) by use of a dual pendulum apparatus. Accuracy scores were highest in a condition where both body and target were stationary and lowest where both body and target were moving. Task conditions requiring motion only of target or of body were of intermediate difficulty, and scores for these tasks were not significantly different from each other. There was evidence of learning across trial blocks for all tasks but no indication that rates of acquisition differed for the task types. Likewise, significant main effects were observed for age levels, but no age/task type interactions were disclosed. Boys were more accurate than girls across conditions, most noticeably on the 2 most difficult tasks. Comparison of subjects' ability to predict, from a stationary body position, the coincidence of the moving target with a standard reference point and their ability to predict the coincidence of their moving body with the same reference point revealed lower error scores on the former prediction task.

More recently Watson and Kimura (1991) investigated target directed motor tasks to examine if men and women may employ a similar or separate type of spatial function to those used in more traditionally-measured spatial abilities. For example, they point out that, generally, males excel on psychometric tests of spatial ability. However, females have an advantage over males on tests of verbal fluency, where words must be generated within the parameters of linguistic constraints and on tests of perceptual speed and accuracy such as scanning arrangements of stimuli for certain items. Females also excel on tests of fine motor control such as assembling small components. In a previous study, aimed at

investigating hand preference under varying task constraints Watson and Kimura (1989) reported significant sex differences on two target directed motor tasks: dart throwing and projectile interception. In dart throwing participants had to hit the centre of a paper target with a standard dart, for the interception task participants used their hands to block oncoming projectiles. In this study they were table-tennis balls, of various trajectories and velocities. Males were significantly more accurate than females with either hand on both tasks, moreover, these differences did not appear to be an artefact of differences in physique or athletic experience. Watson and Kimura further argued that the superiority reported for males on these motor tasks might be related to the already acknowledged male superiority for spatial processing particularly as both tasks required accurate localisation of a point in space. They point out that the spatial analyses required for the performance of these tasks must be carried out in the context of a variety of simultaneous operations such as processing input from various sources and organising movements. In contrast, this is not the case with pencil and paper tests of spatial function. The essence of Watson and Kimura's line of investigation was to examine if the target-directed tasks perhaps reveal some more environmentally relevant spatial function than do typical pencil and paper measures of spatial abilities or do they simply provide a more sensitive measure of the same abilities.

Watson and Kimura (1991) used undergraduate students who were recruited by posters and paid for their participation. These were 48 right handed participants aged from 17 to 27 years. 24 females mean age 21.0 years and 24 males, mean age 19.8. Participants were tested in two sessions over two different days. In the first session participants were given target-directed tasks, i.e., throwing and intercepting accuracy. In the second session they were given tests of spatial ability, reaction time and perceptual speed. In addition they were

given a test of vocabulary such as those which load on a general intelligence factor (Wechsler, 1958). For the interception task participants were asked to block, with a specified hand, table tennis balls fired one at a time from various trajectories from an array of 12 remote control launching devices. Interception was recorded as successful if any contact was made with the ball distal to the wrist flexion skin crease. For the throwing task participants were instructed to attempt to hit the centre of a paper target 3 meters away and elevated 150 cm. They all used a 25 gram throwing darts and threw overarm. In regular dart playing the centre of the target is 1.73m high and the throwing distance is 2.37 m. The dependent measure for the throwing accuracy task was calculated by the mean radial error for the total number of trials. During the break between administering the two motor tasks participants were asked to complete what the authors describe as a Sports History Questionnaire. This was designed to elicit information from each participant regarding their previous experience in a variety of sports, particularly those of a unimanual nature and similar to the motor tasks performed in the present study. During the second session of testing participants were given a battery of tests aimed at investigating spatial ability, reaction time and perceptual speed (see Watson and Kimura, 1991, p. 377 for a comprehensive list). Watson and Kimura found that on the disembedding task (Hidden Figures) and the Paper Folding Test there was no significant difference between the sexes which was contrary to previous literature (eg. McGee, 1979; Wittig and Petersen, 1979) who found a male advantage. In line with previous findings (eg. McGee, 1979; Wittig and Petersen, 1979) there was a trend toward male advantage on the Money Road Map Test but it did not reach significance. In contrast there was a significant female advantage on the Identical Pictures test which supports previous claims that females are superior on tests of perceptual speed and accuracy (Maccoby, 1966; Maccoby and Jacklin, 1974). Overall there was a weak male advantage for the pencil and paper tests of spatial ability and given the

small differences reported by the work of others (Wittig and Petersen, 1979) it is not unlikely that results from any one study may not be consistent with previous findings. However there was a salient male advantage for accuracy on both the throwing and intercepting tasks which was not related to alternative variables such as physique and previous experience. This supports previous research whereby males are reported to be significantly more accurate than females consistently from pre-school age (Lunn and Kimura, 1989) until adolescence (Wickstrom, 1977). Moreover, Watson and Kimura claim that sex differences found in their study are not attributable to differences in overall intelligence as there were no significant differences on the vocabulary test which is claimed to load heavily on the general factor of intelligence (Wechsler, 1958). Watson and Kimura claim that differences found on both motor tasks, i.e., throwing and intercepting, are due to 'some basic ability in which males and females differ to a considerable extent' (Watson and Kimura, 1991. p. 381).

A comparative study of aimed throwing by monkeys and humans reported by Westergaard, Liv, Haynie, and Suomi (2000) confirms this claim. Westergaard et al., (2000) examined hand preference and postural characteristics of aimed throwing in 25 capuchin monkeys and 25 humans (aged 12 - 49 years). The authors sought to directly compare the throwing performances of these primates, particularly the extent to which target distance influences hand preference, throwing posture, and throwing accuracy (TA). For both species the authors found positive correlations between target distances for TA, direction and strength of hand preference, percentage of bipedal versus tripodal throws, and percentage of overarm versus tripodal throws. TA did not vary as a function of right versus left hand use although for monkeys TA was positively associated with hand preference strength. The authors noted a sex difference among humans as males threw more accurately than

females. Between-species analysis indicated that humans exhibited greater right versus left hand use, greater hand preference strength, a greater relative percentage of bipedal versus tripedal throws, and a lower relative percentage of overarm versus underarm throws than did monkeys.

On a final note regarding age and throwing skills one may make reference to a handful of studies that have focused on 'older' age groups of men and women. These, in the main, have investigated whether there is a decline in throwing skills with increasing age. One interesting finding is that of Williams et al., (1991) cited earlier, which examined changes in a maximal skill, i.e., the overarm throw for force. Ten female and 3 male active, older adults (aged 63 - 78 years) were videotaped as they threw tennis balls over a period of two consecutive years. Gender and age differences were examined for movement patterns, ball velocity, and selected kinematic measures. Whilst there was an overall pattern of regression to childhood performance it was noted that older men threw faster, using more advanced movement patterns than older women.

### **2.3 Could the gender balance be changed?**

Whilst there is no question that substantial gender differences in motor performance exist the main question raised by these findings is whether such an imbalance could be addressed when looking at variables such as the nature of extensive practice? Kerr and Booth (1978) aimed to assess the potential effect of specific and varied practice on the development of motor schema. In their study 64 children in 2 age groups (8 and 12 years) were tested on a simple throwing task at the start and end of a 12 week physical education program. For the throwing test, subjects were assigned to either a specificity or a schema group (varied

practice). The task was performed without visual feedback, but knowledge of results was given after each trial. Prior to both tests at the criterion target, the specific group were given practice throws using the criterion target distance, whereas the schema group practised on 2 alternative targets. No differences were found between the 2 groups at the beginning of the program, but on post-test, subjects receiving a variety of practice (schema) on the throwing task performed significantly better than the specific-practice group.

Moore, Reeve and Pissanos (1981) investigated the effects of the direct and exploration methods of teaching on the overhand throwing performance of 58 male and 49 female kindergarteners. Variable throwing practice was provided in the exploration method by allowing subjects to throw 5 different types of balls at a variety of targets. Subjects given the direct method threw only 1 type of ball and received specific instruction and demonstrations. Throwing for distance and throwing accuracy were measured on pre and post-tests. A novel throwing task was administered on the post-test to measure skill transfer. Experimental groups received instruction 3 times a week for 4 weeks in throwing, while a control group received no instruction. Results indicated significant gender differences in throws for distance and accuracy. Novel task data gave no significant effects, furthermore the two methods of teaching did not produce different levels of throwing skill.

Davis (1984) tested the hypothesis that precise visual information about a target's centre would improve accuracy employing 40 male and 40 female undergraduates in two experiments. In their first experiment precise information was provided by a small red dot in the centre of a large white target. Subjects threw chalked tennis balls from a distance of 11 m with and without the dot. Accuracy was determined as the mean absolute and

variable radial error. Results indicate that females especially benefited from the presence of the dot, which supports the hypothesis. In their second experiment instructions to focus on the dot throughout the throw had no effect on throwing accuracy for either males or females. Further analysis indicated that skill was not significant in subject's use of precise information to guide throwing. Large gender differences in both absolute and variable errors, in favour of men were found.

McKenzie et al., (1998) assessed effects of a physical education professional development program on 3 manipulative skills of 4th and 5th graders. Seven schools were randomly assigned to 3 treatment conditions: PES (Physical Education Specialists), TT (Trained Classroom Teachers), and CO (Controls). Students (358 boys, 351 girls) were randomly selected from 56 classes and tested on throwing, catching, and kicking. In the fall (autumn) baseline boys scored higher than girls; 5th graders scored higher than 4th graders. In the spring children in PES schools had improvements of 21%, those in TT and CO schools gained 19% and 13%, respectively. Gain scores were significant for catching and throwing. Intervention effects did not differ by gender or grade. Adjusting for condition, boys made significantly greater gains than girls. These research findings indicated that childrens manipulative skills could be improved by quality physical education programs, delivered by PE specialists and classroom teachers, with substantial training.

Finally, Greenwood, Meeuwssen, and French (1993) randomly assigned 50 males and 50 females (aged 65-75 years) to a Content Dependent Strategy (CDS), CDS with verbal praise, Content Independent Strategy (CIS), CIS with verbal praise, and control. Subjects' motor skills were evaluated using underhand dart throws, dart throws, and ball tosses. Use

of either a CDS or CIS helped the older adults score higher on all 3 motor skills than control subjects. The expected result that the content independent Singer 5-Step Strategy would be more generalisable than a CDS was not verified. The use of verbal praise in addition to cognitive learning strategies did not improve subjects' performance on the throwing tasks. Finally, female subjects were less accurate on each of the tasks than the male subjects.

### **2.3.1 Gender differences and biological factors.**

Evidence that male superiority could possibly be biologically based is reported from research on differences in hormone levels between genders and its effect on performance. Two studies during 1998, by Janowsky et al., (1998) and Jennings, Janowsky, and Orwoll (1998) investigated the affect of hormone levels on performance. The first; Janowsky et al., (1998) examined sex differences in performance on a variety of cognitive tasks in 18 men and 30 women (aged 23-34 years). Performance was correlated with estradiol and testosterone levels in both men and women in order to examine whether hormone levels are related to performance on tasks that either do, or do not, usually show sex differences. Men showed an advantage in performance on tests of spatial cognition as well as a dart throwing task that requires both motor skills and spatial cognition. Hormone levels were related to performance on tasks that showed sex differences as well as those that did not. Estradiol, but not testosterone, was related to block design in women but not men. Women with higher estradiol levels showed superior performance to women with lower levels of estradiol. Performance on the two spatial cognitive measures were related to each other in women, but not men, suggesting that men may use different processes than women to accomplish these tasks. In general, both men and women showed a negative relationship between both estradiol and



testosterone and dart throwing performance. Results do not support the notion that sex differences will necessarily predict the direction of the relation between estrogen or testosterone and behaviour in adulthood. The second study by Jennings et al., (1998) tested the hypothesis that estrogen modulates sequential movement by investigating the reaction time latencies (RT's) and movement time latencies (MT's) of 15 women and 10 men in a choice RT task with sequential responses. Higher levels of estradiol in women's blood were associated with faster total movement time (RT plus MT) whereas Testosterone levels in women's blood were not associated with key-pressing performance. Blood hormone levels in men had no affect on key-pressing performance. Findings are discussed in relation to the knowledge that normal movement depends, in part, on the brain's ability to produce and use dopamine, which regulates basal ganglia function. Behavioural, neuroanatomical, and neurophysiological data suggest that the basal ganglia are critical for the performance of sequential movement. Dopaminergic function is modulated by estrogen in animals and in humans.

Based on the evidence available, two arguments are plausible when attempting to explain gender differences in target throwing. First, it is possible that there are some hard-wired genetic differences between males and females that are expressed during development, inducing boys to engage in more throwing activities than girls and that, as a consequence, enable boys to produce superior adult performance. Secondly, one could argue the opposite account, which suggests that extensive engagement in throwing activities by boys during childhood lead to physiological adaptations of the body and brain. This, in turn, facilitates the development of highly accurate throwing skills that are manifested in adulthood and are observable via such activities as target throwing performance. The latter account is supported by recent research in the growing corpus of literature on the acquisition of expertise (see Ericsson, 1996; Ericsson & Lehmann, 1996; Ericsson et al., 1993).

### **2.3.2 Gender and sex differences and the influence of socialisation.**

Evidence to suggest that male superiority in throwing tasks could be strongly influenced by environmental factors is reported from research on the differing socialisation processes afforded to girls and boys. When examining reviews of sex difference research, only the weakness of 'sex' as a subject variable, particularly as a determinant of behaviour, is apparent. In fact the main finding of almost a century of research has been an overwhelming similarity between the sexes in terms of individual attributes (Connell, 1987). As a consequence, during the past two decades there has been a trend to move away from the more traditional biologically focused research to an investigation of the socially constructed concept of gender and how 'masculine' and 'feminine' identity may affect achievement. It seems from the varied nature of the current evidence that, in areas of research where gender differences are found, these differences are more easily attributable to gender-role socialisation than to 'natural' aptitudinal differences (Eccles and Harold, 1991). For example, in a study by Engel (1994), adolescent girls displayed a decreased level of participation in those sports which were pronounced as stereotypically masculine. Furthermore, there was a decrease in participation levels for girls who were subjected to mixed-sex physical education tuition. This supports previous research which suggests that pressures of socialisation on young women to conform to a male-defined notion of femininity can cause gender-role conflict (Sage and Loudermilk, 1979; Harris, 1980). Studies investigating the acquisition and development of fine motor skills during childhood have shown strong implications as to the influence of psychological and social factors on performance where gender differences have been found (Smoll and Schutz, 1990; Rudisill, Mahar and Meaney (1993).

These findings suggest that the ability to execute fine motor control is not influenced by gender during childhood, but develops into a gender-biased ability under the influence of psychological and/or social factors with increasing age. Thus, arguably challenge the notion that male superiority could possibly be biologically based particularly due to differences in hormone levels between genders and their affect on performance.

### **2.3.3 Gender role conflict in sport.**

Research into gender differences is made even more interesting in the sporting domain as few people would challenge the claim that, generally, sport has traditionally been viewed as a masculine activity (Connell, 1995; Messner, 1996). In fact only recently have women participated in numbers large enough to attract the attention of social scientists.

Socio-cultural factors affecting sport participation have been investigated extensively by Greendorfer (1978). Her pioneering work on sport socialisation during the 1970's and 80's emphasised the role of society, rather than the individual, in sporting choice and opportunity. According to Greendorfer situational factors such as schooling, attitudes of coaches and parents and peer pressure are most influential in the sporting choices made by young girls (Greendorfer, 1978). Her subsequent work raised questions regarding the various methodological and conceptual weaknesses in previous research (Greendorfer, 1987). More specifically she examined the origins and continuing prevalence of the conceptual links between the male gender-role and anticipated sporting activities. Consequently women have been judged, in much of the existing research, against a biased standard of behaviour indicative of a competitive sport structure more applicable to men than women. The concept of gender-appropriate behaviour is intrinsically linked to the broader, sometimes implicit social issues of society at large, and arguably, nowhere in

society is the 'gender role' more explicit, and discriminatory, than in the field of sport. There is research to suggest that sporting activities are perceived as belonging to different categories: gender-specific, gender-appropriate and gender-neutral (Sanguinetti, Lee and Nelson, 1985). Consequently, people who engage in a sporting activity incompatible with their gender are likely to experience gender-role conflict (Sage and Loudermilk, 1979). This conflict is not by any means gender-specific and can affect both women and men equally. Conflict can inhibit performance by affecting psychological variables such as self-confidence and motivation. Gender-role conflict has been known to prevent participation in sport in some cases (Harris, 1980; Eccles and Harold, 1991). For example; Guillet, Sarrazin and Fontayne (2000) examined the affect of gender role attitudes in adolescent females on quitting handball, a perceived gender inappropriate sport. In a 3 year study, 336 French female handballers (aged 13-15 years) completed a French version of the Bem Sex-Role Inventory (Bem, 1974), concerning femininity and masculinity. Results show that feminine and undifferentiated subjects stopped the practice of handball significantly earlier than did masculine and androgynous subjects. After 173 days, 62% of feminine subjects continued playing handball; in contrast, 81% of the undifferentiated, 82% of the masculine, and 87% of the androgynous subjects continued playing handball at the end of the period. After 498 days, 80% of androgynous subjects continued playing handball, compared with 75% of masculine, 68% of undifferentiated, and 60% of feminine subjects. After 823 days, 76% of androgynous subjects continued playing handball, compared with 69% of masculine, 56% of feminine, and 50% of undifferentiated subjects. The authors conclude from their findings that the involvement and perseverance of females in sports remains problematic as long as some activities continue to be viewed as stereotypically masculine. The findings of Guillet et al., (2000) somewhat support the findings of previous research such as that of Lantz and Schroeder (1999) who examined the relationship between

identification with the athlete role and the endorsement of masculine and feminine gender role orientations. College students (173 male and 236 female), incorporating 113 student athletes, completed the Athletic Identity Measurement Scale and the Bem Sex-Role Inventory. Results show that both the 25% highest and 25% lowest athlete identifiers reported similar endorsement patterns of masculinity and femininity. However, some evidence suggests that these separate classifications may result from different perceptions or endorsements of masculinity and femininity. Athletic identity was positively correlated with masculinity and negatively correlated with femininity. Women and non-athletes reported higher correlations between athletic identity and masculinity than did males and athletes.

#### **2.3.4 Gender, self-confidence and motivation in sport.**

Previous research has shown self-confidence to be an influential variable when investigating motor performance (McAuley, 1985; Feltz, 1988). Its effect in a sporting context is therefore often decisive to performance outcome. When investigating gender differences in levels of self-confidence in a sporting context, Feltz and Lirgg (1989) found that women tend to demonstrate less self-confidence than men. A critical point, rarely reported in the research literature, is that situational factors have been shown to affect levels of self-confidence. For example, lower levels of confidence would often be more evident in women when the task was male-oriented, when the situation was competitive or comparative and when feedback is ambiguous (Lenney, 1977). Lack of confidence has been shown to decrease the incentive to participate in a given activity, particularly in the face of adversity, thus limits any possible opportunity to improve (Bandura, 1986). In view of these findings one may argue that the 'position' of women in sport is, from an early age

somewhat debilitating, even exclusionary, due to society's portrayal of sport as a 'masculine' endeavour.

There is also now a vast body of literature (Gill, 1986; Greendorfer and Blinde 1990; Fortier, Vallerand, Briere and Provencher, 1995) aimed at investigating the affects of gender on motivation in sport participation and performance. Much of this research suggests that gender and motivation in sport is embedded in social context, and has roots in psychology, physical education, sport psychology, and competitive athletics. Research on competitive sport orientation suggests that gender influences vary across athletes and within different sports, and that sport and exercise influence self-perceptions, especially body image and self-esteem. Social context influences the role of gender in sport through portrayal of athletes and sport in the media (Knight, and Giuliano, 2001), differentially affecting male and female sport confidence and evaluation of performance, and the perception of differences in sexuality among athletes and within sports. The work of Fortier et al., (1995) investigated motivation from a multidimensional perspective. They examined *intrinsic, extrinsic and amotivation*. They defined *Intrinsic* motivation as doing an activity for itself, out of interest and for the pleasure and satisfaction gained purely from its performance. *Extrinsic* motivation referred to a wide variety of behaviours where the goals of action extend beyond those inherent in the activity itself. Finally, *amotivation*, they likened to the concept of 'learned helplessness'; Individuals are said to be amotivated when they are unable to perceive contingencies between their actions and the outcome of their actions, they are neither intrinsically or extrinsically motivated. Fortier et al., (1995) went on to investigate several sub-types of motivation, as identified by Deci and Ryan (1985). Noteworthy, are the main findings of their study: Overall women athletes demonstrated higher levels of intrinsic motivation but lower levels of extrinsic motivation

than men using these sub-type measures. Lower levels of amotivation were also reported by women athletes.

More recent research by Amorose and Horn (2000) examined the relationship among athletes' intrinsic motivation (IM), gender, scholarship status, perceptions of the number of their team mates receiving scholarships, and perceptions of their coaches' behaviour. College athletes aged between 17 - 23 years ( $n = 386$ ) from a variety of Division I sports completed a series of paper-and-pencil questionnaires. Multivariate analyses revealed that (a) scholarship athletes reported higher levels of IM than did non-scholarship athletes, (b) male athletes reported higher IM than did female athletes, and (c) perceived coaching behaviours were related to athletes' IM. These findings support the work of Koivula (1999) who investigated the possible affects of gender typing, as measured by the Bem Sex Role Inventory (BSRI), on motives given explicitly for sport participation and if there was any relationship between motives for participation and the time spent participating in sports. Participants were 202 female (mean age 26 years) and 208 male (mean age 24.9 years) college students. Several differences between groups of individuals were found regarding motives for participating, actual participation and the relationship between the motives given and the actual participating time. Moreover, some of these differences might arguably be explained by the social construction of male-female relations that work to maintain, strengthen and naturalise gender differences.

The psychological concepts of motivation and self-confidence have also been investigated in sport specific situations. For example, Meyers et al., (1999) examined the mood and psychological skills of elite and sub-elite equestrian athletes, this being particularly interesting in view of equestrianism arguably being a gender neutral sport. For the purpose

of their study, 54 equestrian men and women (aged 15 - 64 years) completed a battery of psychometric inventories. These included the Profile of Mood States (POMS; McNair, Lorr and Droppleman, 1992), and the Psychological Skills Inventory for Sport (PSIS: Mahoney, Gabriel and Perkins, 1987) during the Olympic Trials and various other equestrian competitions of similar standing. Data were grouped for analyses by rank (elite, sub-elite), event (dressage, show jumping), and descriptively by gender. Elite competitors exhibited significantly higher anxiety management and concentration than sub-elite athletes. Males tended to exhibit higher vigour, but less tension, depression, fatigue, confusion, and total mood disturbance than females. Male athletes also scored higher in anxiety management and confidence, but lower in motivation than female competitors. Earlier researchers Chantal, Guay, Dobрева-Martinova, and Vallerand (1996) conducted a multidimensional analysis of sport motivation in relation to elite performance and gender. Subjects were 98 Bulgarian top athletes, 35 females and 63 males, (mean ages 19 and 20 years respectively) who specialised either in canoe, biathlon, figure-skating, boxing, tennis or skiing. Subjects athletic performance in national and international events over the previous 2 years were documented in addition to their completing a Bulgarian version of the Sport Motivation Scale (SMS). The scale, which is based on the tenets of the Self-Determination Theory, assesses intrinsic motivation (IMO), self-determined extrinsic motivation (EMO), non-self-determined EMO, and motivation. Results showed that title and medal holders displayed higher levels of non-self-determined EMO and motivation than the less successful athletes. In relation to gender, results revealed the motivation of female athletes to be more strongly characterised by IMO. The authors concluded these results highlight the important role of motivation in elite sport performance.



Finally, Meyers, LeUnes and Bourgeois (1996) administered the Psychological Skills Inventory for Sports (PSIS) to 149 male and 66 female collegiate rodeo athletes and performed Multivariate Analysis of Variance (MANOVA) by event, gender, nature of competition (contact, non-contact), and athletic level of skill. Psychological constructs identified by the PSIS included anxiety management, concentration, confidence, mental preparation, motivation, and team emphasis. Wilks's criterion indicated no significant differences in psychological skills across events. Males scored significantly higher in anxiety management, concentration, and confidence than did females whereas highly skilled subjects scored significantly higher in anxiety management, concentration, confidence, and motivation than did lower skilled subjects. The authors concluded from their findings that collegiate rodeo athletes exhibit psychological skill patterns inconsistent with athletes in more traditional sports and that assessment of psychological skills may serve to enhance predictions of athletic potential in this particular sport.

There has been no previous research to examine the psychological concepts of self-confidence, motivation and gender-related performance using the target sport of darts but contemporary research has investigated alternative attributes that arguably could be contributing factors to competent dart performance. For example in a study by Hudgens, Fatkin, Billingsley and Mazurczak (1988) women were shown to be superior to men in a study of hand steadiness that used pistol firing as its dependent measure. Moreover, girls games were also shown to be more conducive to the practices of target sport, preferring activities that require turn-taking, orderly sequences, partial body involvement and solitary practice (Ignico, 1989).

### **2.3.5 Throwing, gender and spatial abilities.**

Watson and Kimura (1991) propose that superiority shown by males on throwing (and intercepting) tasks could possibly be related to some kind of spatial ability rather than due to biological differences. In a broad sense spatial ability could be an integral element necessary for the production of accurate aimed movements as such movements require the precise localisation of a particular target in three dimensional space (Carson, 1989). Moreover, significant correlations have previously been found between pencil and paper measures of spatial ability and throwing accuracy (Jardine and Martin, 1983). Based on the work of previous researchers spatial abilities have been subsumed into two broad categories: orientation and visualisation (McGee, 1979; Wittig and Petersen, 1979). Orientation is described as the ability to distinguish changes in the way in which spatial configuration is presented, such as in disembedding tasks (McGee, 1982) whereas visualisation relates to the ability to understand imaginary manipulation of an object resulting to changes in its form and/or configuration. However, it must be noted that there is not a universal consensus on the validity of this dichotomy as there is considerable overlap of the functions attributed to each and evidence to suggest that correlations exist between some abilities raise questions as to their specificity (Newcombe, 1982). In Watson and Kimura's (1991) study the measures of spatial ability were essentially uncorrelated with throwing accuracy and on this basis they suggest that 'it seems probable that the type of 'spatial' analysis contributing to the motor tasks is a somewhat separable function from visualisation/orientation' (p. 382). They therefore suggest it may be beneficial to distinguish between spatial transformation functions, incorporating both orientation and visualisation and a spatial targeting/localisation function. Watson and Kimura claim that, the form of spatial analysis employed in their study tasks may be related to the process of 'object localisation'. Namely, the determination of an object's position in the environment, (von Hofsten and Lindhagen, 1979; von Hofsten and Rosblad,

1988), which closely resembles target localisation in motor tasks. In their conclusion Watson and Kimura further draw on research from an evolutionary perspective, particularly examining those behaviours closely related to activities of survival in the 'real world', such as hunting and defence. The importance of throwing ability has been stressed by a number of authors in the area of human sociobiology (Jardine and Martin, 1983; Kolakowski and Malina, 1974.) and even suggested as a mechanism of selection for spatial ability. The sex differences in spatial ability found by Watson and Kimura do suggest these differences are more pronounced in tests that are congruous with human ethology. For example; males barely outperformed females on the pencil and paper tasks, if at all, but performed significantly better on the viewfinding task which is a less abstract form of mental rotation. Moreover the motor tasks, i.e., throwing and intercepting which Watson and Kimura argue are closely related to ecologically-relevant operations showed a large male advantage. They further claim that 'it appears that the male advantage in spatial function may be more pronounced for tests conducted in a less artificial or clerical milieu, requiring 'real world' three-dimensional operations' (p. 383).

A group of researchers, Brouchon, Joannette and Poncet, 1984 and Stelmach and Larish, 1980, argue that differences in spatial motor functioning must be discussed within the conceptualisation of 'intrapersonal' and 'extrapersonal' space. Intrapersonal space being where a given task or behaviour is executed in close proximity to the body whereas extrapersonal space refers to reference points or targets at some distance from the body. There is evidence to suggest that different central functions are responsible for each type of movement (Brouchon et al., 1984; Stelmach and Larish, 1980). In Watson and Kimura's research the targets in both the throwing and intercepting tasks were located in what would be classified as extrapersonal space and a male advantage was reported for both tasks. Previously, authors have reported a female advantage tasks performed in intrapersonal space such as the precise positioning of

digits (Denckla, 1974), the fast and accurate execution of a series of manipulations (Kimura, 1986) and a host of perceptual-motor skills (Maccoby and Jacklin, 1974). Clearly the performance of dart players is always carried out in extrapersonal space which may be a contributing factor to superiority of men over women found with the data in the current research and reported in this thesis. Watson and Kimura argue that sex differences based upon this classification i.e., 'intrapersonal' and 'extrapersonal' space, is not surprising when one looks historically at the division of labour between the sexes in hunter-gatherer societies. Even today across 224 societies hunting, fishing and trapping of animals are almost exclusively male occupations whereas food preparation and gathering, sewing and weaving are almost exclusively performed by women (Daly and Wilson, 1983).

Based on the findings of their research Watson and Kimura (p. 384) make three claims; first that the spatial analysis involved in target-directed motor tasks is a separate ability to those measured by the viewfinding and pencil and paper tests of spatial ability. Secondly, the weak sex differences found on the pen and paper task, as opposed to the viewfinding task,

may imply that sex differences in spatial function could be most pronounced in tasks that have a 'real world' dimension. Thirdly, the sex differences found in viewfinding and target-directed tasks could arguably reflect an evolutionary division of labour between sexes, resulting in a male advantage for behaviours directed at distant objects and a female advantage for behaviours performed in close proximity to the body.

### **2.3.6 Throwing, gender and physical differences.**

Watson and Kimura (1991) investigated the effect of physique, along with previous experience, on performance of throwing for accuracy and found male superiority to be independent of physical factors. They argue that although longer arms and greater height may be an advantage in throwing for velocity they suggest these two attributes could be a disadvantage when throwing for accuracy as increased arm length would serve to 'amplify articulatory errors or other noise introduced at the elbow or shoulder. Thus, for example, a fixed amount of error in articulating the elbow during throwing would result in relatively larger-amplitude errors at the distal end of the arm in long-armed males than in shorter-armed females' (Watson and Kimura, 1991. p.381).

Wickstrom (1977) argued that where throwing tasks require high velocities or long distances male superiority has been attributed to a bio-mechanical advantage due to females being unable to separate pelvic and spinal rotations. But in the study by Watson and Kimura, and those reported in this thesis, which investigate short range throwing for accuracy, (less than 3m for both studies) high velocity delivery was not required. Moreover, movements made to execute the throwing action were almost exclusively confined to the distal joints of the arm i.e., fingers, wrist and elbow, and to a lesser extent the shoulder. Arguably then any male superiority in the tasks reported in this thesis are almost certainly not attributable to a bio-mechanical male advantage. Watson and Kimura further tackle the question of male superiority by investigating arm length and height suggesting these two variables may be contributing factors. Although conceding that longer arms and greater height may be an advantage in throwing for velocity, they in fact, state that these two attributes could be a disadvantage when throwing for accuracy. The investigation of arm length, reported in phase 1

of this thesis, gave no indication that having longer arms made any significant contribution to male superiority in dart throwing. In fact when arm length and height were controlled for male performance was still significantly superior to that of females.

### **2.3.7 Meta-analysis and age and gender research.**

In areas of research where a large corpus of literature exists a meta analysis of such findings has often shown to be of interest. Thomas and French (1985) conducted a meta-analysis of 64 studies that reported gender differences on motor performance during childhood and adolescence. Findings yielded 702 effect sizes based on data from 15,518 female and 15,926 male 3-20 year olds. Age was regressed on effect size, and the relation was significant for 12 of 20 tasks (e.g., balance, catching, grip strength, shuttle run, throw velocity, tapping). Several types of age-related curves were found; the curve for a throwing task was the most distinctive. Five of the tasks followed a typical curve of gender differences across age. For eight tasks, gender differences were not related to age, and effect sizes were small.

## **2.4 What evidence for environmental factors?**

The argument put forward here is that age related factors in the development of motor skills are not only dependent upon maturation but also on the opportunity to respond effectively to appropriate environmental stimuli. Whilst the focus of this review is on environmental stimuli it is noteworthy that the nature/nurture debate has not been ignored insofar as development of motor skills are concerned. Therefore, arguably, the extent to which abilities are developed are determined by both inherited characteristics and environmental factors, with one's capacities being restricted within the framework

provided by genetics. But, to what extent do inherited characteristics determine the potential to which motor skills can develop?

Early studies examining identical and fraternal twins on a battery of motor tasks (McNemar, 1938) and reaction time tasks (Scarr, 1966) showed that identical twins had a higher degree of congruence in performance than did fraternal twins. Thus suggesting that genes could play a role in determining motor development. However, this is not the main aim of the present review. What is most relevant is the affect that environmental stimuli, in features such as practice and instruction, may have on development of motor skills. The argument being that, if the opportunity to develop a behaviour is missed at the time during development when that particular behaviour would usually be expressed, then it is unlikely to develop to its full potential at a later stage. In other words, behaviours learned in a particular period of development may be crucial in later performance. Whilst early works of Hicks and Ralph, (1931) and Wenger, (1936) found that adult subjects in an experimental setting, who were trained in particular perceptual motor tasks, were generally not superior to controls in the same task. Similar accounts seemed to have been echoed with younger participants. Miller (1957) examined the overhand throw of first grade children who were coached for 26 sessions, each of 20 minutes. Although the group under instruction performed better than a control group the differences did not reach significance. McDonald (1967) also found that practice did not significantly improve the performance of 8-year-old boys and girls on a throwing task.

Staats (1968) believed that behavioural patterns such as co-ordination and balance develop in a similar way in all children. What is crucial however, is the correct timing for intervention. For example Scott (1962) wrote: *'The results...are more satisfactory than*

*those obtained by trying to teach complex physical skills directly at an early age. Most children are not able to perform activities requiring good co-ordination of the whole of the body much before the ages of 7 or 8, and introducing them too early to such activities only results in unskilled performance or failure'.* Thus, encouraging younger participants to learn a motor task prior to their reaching an appropriate level of maturation is arguably a futile exercise. Staats (1968) further argued that individual differences in development and skill acquisition are a function of differential training techniques. In particular he placed great importance on reinforcement opportunities; i.e., what is reinforced and how it is reinforced. Staats (1968) favoured a systematic reinforcing training programme for more rapid motor development. This view coincides with later research on learning in infants which focused on two main considerations; the usage of operant learning in newborns and the application of effective reinforcers in the learning situation (Elkind and Sameroff, 1970).

Thus a great deal of research is still needed regarding optimum learning periods for acquiring motor skills as much disagreement still exists. These skills are based not merely on age but on the relative rate of maturation of various organs. Any attempt to teach a child too early in the course of their development may result in their learning bad habits, or simply learning “not to learn”, either of which may greatly handicap them in later life.

However, there is more consensus, albeit with a few exceptions, on the issue of gender as a contributing factor in the performance of motor skills. The overall consensus, as will be reviewed in the next section, is that of male superiority at all ages in throwing skills with males also benefiting more than females from any “environmental” interventions in particular in throwing skills.



## **2.5 Hand preference and practice.**

Indirect evidence that male superiority cannot be overcome by practice is reported from research on hand preference and practice effects between genders. Espenschade, (1958) examined the throwing accuracy of 40 men and 30 women college students (mostly physical education majors). The participants were blindfolded, given half-pound sandbags and asked to hit the centre of a concentric circle on the floor, 12 ft. in front of them. 50 tosses were made with participants changing hands after each 5 tosses. An equal number of each sex started with their preferred and non-preferred hand. Subjects were informed of the result of each toss in terms of a score to indicate direction and amount of deviation. Deviations in direction were small and showed little change. Distance scores improved rapidly and the improvement made in 50 trials was highly significant. Men's scores were superior to women's in both the preferred and non-preferred hand but in neither sex were differences between hands significant.

Simon (1964) conducted an experiment on hand steadiness examining the relative performance of the preferred and non-preferred hands in right and left-handed subjects. Handedness was self-classified with strongly right-handed and strongly left-handed subjects who were instructed to perform a hand steadiness task with one hand and then the other. Results indicate that, while over-all performance is significantly better with the preferred hand, steadiness cannot be regarded as a sensitive index of handedness. A predicted interaction between steadiness and hand preference was significant for male subjects only. Further research by Dunham, (1969) examined forty 17 to 19 year old subjects on the effects of practice on a pursuit rotor task in 2 ways using 1 of 4 different orders of practice. Two groups alternated practice hands (serial), and 2 completed practice with 1 hand then the other (sequence). One group in both the serial and the sequence order began with the preferred hand and the other with the non-preferred hand. Results suggested that ordering of practice is not important.

More recently, Wild and Payne (1983) investigated psychomotor reminiscence in 40 female and 40 male undergraduates as a function of sex, handedness, and hand used in practice. Half of the subjects were right-handed and half were left-handed. Subjects were required to use mirror vision to track a small silver target. Ten of 20 subjects within each combination of sex and handedness were assigned without bias to practice with the right hand, while the other 10 practised with the left hand. After instruction and demonstration, all subjects executed a 9-trial sequence of practice and rest. Performance scores showed that women reminisced more than men when practice was conducted with the preferred hand but not when it was conducted with the non-preferred hand. Hand preference was not a significant factor in men's reminiscence.

Reddon, Stefanyk, Gill, and Renney (1985) assessed 12 self-reported dextral adults (aged 20-36 years) with a hand dynamometer with 10 trials per hand for 10 consecutive weeks. Test-retest reliability was high for both preferred and non-preferred hands. Fatigue effects were significant for both sexes and hands, except for women's preferred hand. Skill acquisition effects were significant for men's non-preferred and women's preferred hands.

Finally, Bryden and Allard (1998) examined the hypothesis that temporal differences between the hands are often attributed to greater preferred hand practice in everyday tasks. Therefore the affects of extended practice on manual asymmetries was investigated using a pegboard task. Five trials for each hand were performed on the Annett pegboard by a consistent right hander, every day over a period of thirty days. Analysis revealed that overall, extended practice benefited both hands, with the preferred hand improving at a significantly faster rate than the non-preferred hand. The difference between hands, therefore, increased significantly over time.

## **2.6 Chapter summary and comments:**

Chapter 2 has provided a comprehensive definition of the skill of throwing in its several different guises including underarm, sidearm and/or overarm. Moreover, how this particular human skill develops from an aimless activity during the early months of life to a deliberate, meaningful action in later years has been discussed. Much of the research reviewed has highlighted the differential rates of development for throwing, arguably which are determined by maturation and gender. Findings in the main suggest that older children are generally more proficient than younger children, and boys generally more proficient than girls. There is also some evidence to suggest that 'optimal learning periods' exist for the acquisition of certain skills. Moreover, if the opportunity to learn these skills at this particular period is missed then developing a skill to its full potential may be inhibited. Although evidence for gender differences in favour of boys appears to be strong, research thus far has failed to provide compelling evidence as to whether environmental or biological factors have the most influence on the development and 'end product' of throwing skill. Evidence in support of practice (environmental) as a factor that can improve throwing skill has been quite compelling with the more recent work on the influence of hormones (biological) in throwing ability, although viable, less convincing. Overall the evidence to date indicates that although a gender imbalance undoubtedly exists there is also ample evidence to suggest this can be addressed.

Noteworthy to report here is that much of the research cited in this review was based on naïve groups of boys and girls and/or college students for whom task participation had an element of novelty, rather than a test of skill for which they had extensively trained. Even when laboratory based training was performed it was short lived and was not robust enough to provide evidence for any long term effects of practice when learning a particular skill.

Boys may do better than girls because they are more interested in the type of task they are asked to perform. Noticeably, when girls and boys were tested in a hopping task girls did

significantly better than boys (Gutteridge, 1939). Furthermore, boys may benefit from training in comparison to girls, particularly if the training given is more gender specific and modelled on tasks found to be more enjoyable to boys. So, how much can one learn about gender differences in target throwing tasks by targeting naïve boys and girls in a sterile experimental setting. More specifically, how much can one learn about expertise in a perceptual motor skill by targeting naïve children and adults. Such considerations raise the obvious question as to why the performance of an elite group of men and women, who have deliberately worked toward the perfection of their throwing skill, has never been investigated previously? One reason may be a practical one. After all, targeting elite participants is not as easy as recruiting college students and /or children. Indeed, as a researcher, one has to consider ethical issues when recruiting any participants there are no doubt even greater ethical and practical considerations when targeting an elite group of performers. For example; would it be practical to approach an elite performer such as dart champion during a match to examine their target throwing skills? Would it be ethical to expose a professional performer to unnecessary experimental trials that may hamper their performance? Surely such considerations have prevented previous researchers from targeting elite performers for the purpose of research on target throwing. Thus, this thesis, with its focus on elite dart players as participants has overcome many of these limitations and, it is hoped as a consequence, it offers a unique contribution to the research literature in this area. However, before engaging in actual performance of expert target throwing participants it is important to review what the literature on expertise, throwing and sporting activity has to offer thus far. This will be documented next.

## Chapter 3: Development of Expertise.

### 3.1 Preface.

The previous chapter focused on some of the key factors contributing to the performance of throwing skills. It was argued that, factors such as age, gender and practice might play a significant role in how best one may perform the motor skill of throwing. A noteworthy point relating to much of the research highlighted in the previous chapter is the fact that, in the main, children and “naïve” adult participants were the subject of investigation. In this respect the theme of this chapter is somewhat different. Instead of targeting research on children or novice participants to provide arguments for research on throwing skills, the focus now turns to research aimed at investigating those individuals labelled as professionals, experts, gifted, talented and so on. In a sense the focus of investigation afforded to this particular group of participants is likened to an *ex-post-facto* research approach upon which excellence in a particular skill domain is reached either as a result of inherited “natural” ability, or by the utilisation of external “environmental” factors. Therefore the immediate question one may ask is that if one has acquired a level of excellence in a particular skill what are the most likely contributing variables; those intrinsic to inherent “natural” ability, those influenced by the affects of “environmental” factors, or both? More specifically, if one has reached to excellence in target throwing is it because they are “inherently” talented in this skill or have they acquired excellence as the result of an enriched “environmental” support system? Most appropriately, and from a logical historical viewpoint the literature review aims to unravel some answers to the above questions. This will begin by addressing the age-old issue of nature versus nurture as mediating factors in the acquisition of expertise in particular domain (Galton, 1869/1979).

Whilst the rise of cognitive psychology (Tolman, 1954), along with recent developments in the study of expert performance and skill acquisition (Ericsson et al., 1993), have opened new avenues for consideration, it will nevertheless be argued here that, as yet, none of these paradigms have been conclusive in providing evidence as to which factors are the main protagonists in the route to expertise in a particular domain.

More recently research incorporating sporting behaviour has provided an alternative medium for examining the extent to which cognitive psychological theories, as opposed to theories of motor skill acquisition, may contribute to the acquisition of sporting excellence. However, conclusions regarding the extent to which cognitive knowledge as opposed to motor skills *per se* contribute to expertise is still the subject of extensive debate. For example, research on how expert chess masters differ from novices (Charness et al., 1976) could only add to our knowledge of the contribution that “cognitive” factors make to expertise in this sporting domain. Whilst, arguably, research on how expert wrestlers differ from their novice counterparts (Hodges and Starks, 1996) has problems differentiating those skills that are predominantly cognitive in nature, namely strategies, from those skills that are more reliant on motor skill acquisition. Adding to the problem is the issue of what is “*measurable*” when investigating the acquisition of skill in a particular domain. Moreover, to what extent can distinctions between inherent versus environmental factors be isolated and controlled for in any investigation?

The arguments proposed in the research reported in this chapter, therefore, are not necessarily intended to imply total disqualification of one factor, say heritable individual differences in favour of another factor, say deliberate practice, but are somewhat more focused on finding a compromise. For example; are there particular aspects of human expert performance more likely to benefit from say deliberate practice and/or strategic knowledge or from a heritable gift not

common to other individuals? This is perhaps a key issue to consider in reading the following sections.

Finally, in view of the above arguments, it is proposed here that an investigation of elite dart players would be a fruitful line of research in tackling the many challenges faced by researchers whose focus is to uncover the factors responsible for the acquisition of expertise in a particular domain. This is because the route to excellence in elite dart playing arguably reflects the pure mastery of target throwing with perhaps little or no role for the possible contribution of knowledge based strategic factors. To clarify the distinction of the minimal role that cognitive/strategic processing may play in dart playing expertise; Assume that two robots were programmed to exhibit accurate and precise target throwing skills. Thus, no intended shot was missed, moreover, the only further condition to be met by the robots was to learn the simple rules of darts, i.e., to finish on a double. In this hypothetical scenario the robot that throws first would always be the winner regardless of which dart finish it may choose. Thus, contrary to a situation whereby one engages two computers to play chess matches against each other, whereby superior strategies are crucial to the outcome of the match, the two expert dart playing robots need only to be accurate in their target throwing. Regardless of their choice of dart finish they would successfully complete the match due to their 100% accuracy, therefore, using strategies to leave a favourable double would be unimportant. Hence, as will be argued in the general discussion, 'strategies' in dart playing are not akin to the cognitive/strategic processes that Charness and colleagues were referring to, whereby strategies 'directly' influence game performance and outcomes. Arguably, in dart playing strategic process are 'indirect', and more "contextual" in nature, such as the choice of playing arena, or how psychologically prepared one's self is for competition.

The opportunity to adopt both an experimental and non-experimental approach to investigate target throwing skill and dart playing performance amongst elite men and women may enable one to answer many questions of theoretical and practical interest to both psychologists and sporting professionals. Whether those gender differences exhibited amongst children and naïve adult participants are mirrored amongst elite dart players and, if so, the extent of such differences, has implications for issues raised in Chapter 2. Moreover, considerations of factors contributing to excellence in target throwing skill and dart playing as a professional sporting event has more specific implications for issues raised in this chapter.

### **3.2. Definition of Expertise: Historical Background.**

Ever since the earliest records of human achievement have been documented there have been individuals in almost all walks of life who have exhibited exceptional performance when compared to their peers. Depending on the domain of expertise (the term expertise is cited in this thesis interchangeably with expert performance) and the historical context, such individuals have often been labelled ‘exceptional, superior, gifted, talented, specialist, expert or even lucky’ (Ericsson and Smith, 1991 p. 2). However it is important to note that a given terminology such as "gifted" in parallel to an "expert" may be taken by different semantics in different contexts. The important consideration is a definition in which one distinguishes an individual from their contemporaries in a particular domain. For example, a gifted individual may be an ideal label for a child with exceptional talents for say music when compared to their peers, who are showing less, or no talent for music. However, in sporting events the terms "professional standing", "world class" or "expert" may be used more appropriately when making a comparison between those sports men and women engaged in the same sport to those labelled as "amateurs"



or "novices" in that sport. With the latter in mind, the general literature reviewed herein, whilst covering various themes of expertise is mainly reported with the intention of paving the way for research on various levels of sporting elitism. Also noteworthy at this point is that when reviewing research on the acquisition of expertise one has to bear in mind that what may be defined as an expert level of performance in a particular domain at an historical moment may vary considerably over time. For example; in many disciplines in track and field athletics world record-breaking performance of 50 years ago would nowadays reflect club or regional standard for today's athletes.

### **3.3. Nature versus Nurture debate: Early accounts of expertise.**

The first scientist to investigate the possibility that exceptional performance, even across several different domains, could have a common set of causes was Sir Francis Galton. On investigating family relationships among people in the British Isles he found that eminent individuals were more likely to have close rather than distant relatives that were also eminent although not necessarily in the same domain. From these findings Galton, (1869/1979) claimed that eminence in a particular domain must be transmitted from parents to their offspring and is therefore a virtually inevitable consequence of inherited natural ability. Galton, (1869/1979) distinguished three factors necessary for the acquisition of exceptional performance; first, the requirement of motivation and perseverance, secondly, adequate power of doing a great deal of laborious work and thirdly, innate ability as the predominate source of heritable individual differences that serve to determine expert performance.

Systematic examination of the gifted began with the work of Terman (1924) whose longitudinal study investigated 1,528 children with exceptionally high IQ's averaging 151. Terman found the children to be socially well adjusted, well rounded individuals who all grew to be successful professionals in adult life. However, none made widely recognised intellectual breakthroughs which, arguably, suggests that even exceptionally high IQ's alone, do not lead to creative eminence. Moreover, whether or not exceptionally high IQ is a predictor of professional success could not be established, as Terman did not control for the possible affects of extraneous variables such as socio-economic status. Since the work of Terman scientific investigation has uncovered alternative variables such as motivation and hard work as important predictors of giftedness. Moreover, there is very little evidence to suggest there is any correlation between giftedness, IQ and outstanding ability in different areas (Winner, 2000).

However, many criticisms aimed at the early reports of exceptional performance are due to their anecdotal, unscientific nature. For example; many of the descriptions of the young genius Gauss are based on unsupported anecdotes recalled by himself as an ageing man (Buhler, 1981). The need to establish a scientific basis on which to investigate and report exceptional human achievements was realised and this shift started with the rejection of unverifiable evidence and the acceptance of identification and systematic collection of empirical evidence that meets standard scientific criteria.

### **3.3.1. Nature versus Nurture: The contribution of Cognitive Psychology.**

Whilst earlier research on issues related to expertise may be criticised on the stringency of its unscientific method of investigation (e.g. focusing on an introspective approach and lacking strong theoretical background) the rise of cognitive psychology during the 1950's arguably

prompted a significant turning point. For not only did the cognitive psychology paradigm offer a more stringent experimental approach to the study of expertise, but also provided some degree of clarity to what may be the extent of “environmental” and “inherent” based factors responsible for expert performance and how they exert their influence. Cognitive psychological theories and research are based on the premise of understanding human's *as if* they are a system for processing information (Underwood, 1978). Within such an information processing paradigm, two key assumptions play an important role: First, the availability of the general structure upon which information is processed e.g. one's memory system and knowledge structure. Secondly, the efficiency upon which such structures may operate. To clarify; in order for humans to read there is a need to have the appropriate memory and knowledge structures in place to enable the decoding of linguistic information. However, whether the task of reading is executed efficiently or not is reliant upon the system to function efficiently, i.e. faster processing of the intake of information, transfer to long term memory and so on. Such a general paradigm, when linked to issues raised by the nature versus nurture debate on the development of expertise brings in an interesting dimension. The “inherent” abilities that Galton and colleagues were in much support of are perhaps likened to knowledge structures and memory bases in human information processing. Whereas “environmental” factors supported by Ericsson and colleagues are perhaps akin to those external factors, such as the role of learning, that may contribute to a more efficient processing system. Returning to the example of reading, Galton and colleagues may therefore have argued that a gifted reader is one that has “inherited” an exceptionally superior memory structure or possess fundamentally different knowledge structures. Alternatively supporters within the “nurture” camp of researchers may argue that a gifted reader is one that has been taught to use their memory system efficiently thus facilitating the acquisition of expert reading performance. Adopting such considerations and incorporating them within research into expertise has led to advances in our understanding of both the contribution of knowledge based

factors as opposed to those factors more reliant on external intervention in the development of expertise, an issue that is dealt with in the forthcoming sections.

#### **3.3.1.1. The role of knowledge based structures.**

The work of de Groot (1946/78), later extended by Chase and Simon (1973) has often been attributed as the primary stimulus for the emergence of systematic research on expertise, particularly the paradigm by which experts are compared with novices in a given domain. This is mainly due to their providing a general theory for the structure of expertise which incorporated empirical predictions that could be utilised as a framework within which the acquisition of expert performance could be studied in "any skilled task (e.g., football, music)" (Chase and Simon, 1973. p. 279). The work of de Groot and Chase and Simon may be viewed more as indicative to our understanding of domain-specific knowledge aspects of expertise, bearing in mind that the reader may make several inferences from what is reported in this section. Such as, are knowledge based aspects of expert performance inherited or well trained and organised as a result of external intervention? Whilst it is not the aim of this thesis to resolve the distinctions made here, it is pertinent to report this body of literature in order to emphasise the point that factors other than *purely* environmental or physical may be responsible for expertise in sporting domains. For example, a person exhibiting expertise in say playing football may not only be skilled in the physical aspects of the sport but more so in rich knowledge patterns of the game.

Returning to earlier accounts of knowledge based research, Chase and Simon (1973). investigating chess playing, demonstrated that stronger players are distinguished from weaker players by their perceptual ability to correctly reproduce large patterns of chess positions after only a few seconds of viewing. This is opposed to the in depth search strategies employed by

weaker players. This research implied that specialised structures of knowledge were in place, but the nature of this knowledge and its interactions with general heuristic processes was not well understood. "Clusters of related pieces in a position are recognised as familiar constellations; hence, each cluster is stored as a single symbol. Less skilled players have to describe the board as a larger number of simpler chunks, - hence cannot hold all of the information required to reproduce the board in short-term memory. When the same number of pieces is arranged on the board at random, few of the resulting configurations are familiar even to grandmasters. They then need more symbols to describe the position that can be held simultaneously in short-term memory, hence, they perform as poorly as weaker players" (Newell and Simon, 1972. p.781). de Groot (1946/78) found that even during very brief (5 second) exposure to chess positions, in fact during their initial perception, chess experts could select superior moves. According to de Groot this finding implied pattern-based retrieval from memory rather than the results of extensive search. Chase and Simon argued that chess expertise was mediated by an extremely large number of patterns held in short term memory, possibly over 10,000, that served as retrieval cues for appropriate chess moves for the corresponding chess positions. Recent research has suggested that the number of patterns, also known as chunks, are much larger than first thought and probably range between 1000,000 and two million (Richman, Gobet, Staszewski and Simon, 1996). Moreover, Chase and Simon's assumption, namely, that cues are retrieved from short term memory, because storage of generated products in long term memory is not possible during brief (5 second) exposure, has now been rejected for expert performance in chess and other domains (Chase and Ericsson, 1982; see Ericsson and Kintsch, 1995 for a review). Although Chase and Simon (1973) proposed that most forms of expertise are the result of vast amounts of knowledge and pattern-based retrieval mechanisms acquired over many years of experience, subsequent research has found that expertise may not be the result of simply *more* knowledge, but better *organised*

knowledge (Chi, Glaser and Rees, 1982). Thus, the study of expertise from its earliest origins, provides evidence of a knowledge-competence dimension as a primary focus. The emphasis on the importance of knowledge based strategies rather than power based strategies extended to AI research (Minsky and Papert, 1988).

Based on the findings of their research Chase and Simon (1973) proposed that expertise in "any skilled task (e.g., football, music)" (p.279) was the result of vast amounts of knowledge and pattern-based retrieval acquired over many years of experience in the associated domain. The Chase-Simon theory has been influential in the research of expertise as it provides an account of experts' superior memory only for stimuli from their domain. However, these findings have been demonstrated in other areas of expertise, such as chemistry and social science (Voss, Green, Post and Penner, 1983, cited in Ericsson and Lehmann, 1996) and bridge (Charness, 1989).

This viewpoint of the acquisition and development of expertise is consistent with theories of skill acquisition based on the assumption that knowledge is initially acquired and subsequently organised into procedures for responding to specific situations encountered in a given domain (Anderson, 1983., Fitts and Posner, 1967). Moreover, researchers have since been able to report numerous examples for superior strategies used by experts in comparison to novices. For example, increased planning and superior strategies employed by experts in bridge (Charness, 1989) and snooker (Abernethy, Neal and Koning, 1994) are mediated by similar mechanisms as those used by experts in chess. Further evidence can be found for perceptual-motor experts in sports where elite performers have been shown to extract and recall more information following brief exposure to representative game situations than non-elite performers (Allard and Starkes, 1991). These findings suggest that elite performers are able to form internal representations of

complex game situations that facilitate their ability to predict and anticipate probable actions of opponents therefore enabling them to select the most appropriate actions in response. For example; Helsen and Pauwels (1993) found that world class soccer players not only selected the most appropriate actions but selected them faster than soccer players of a lesser standard. Furthermore, elite performers in racket sports are able to anticipate the outcomes of their opponents actions even before the ball has made contact with the opponents' racket (Abernethy, 1991). Evidence from expert performance in other activities such as typing (Salthouse, 1991) and juggling (Beck, 1989) has also shown that experts are able to predict future events based on cues available in their environment more efficiently than non-experts, thus giving them more time to prepare their actions.

Whilst the aforementioned research has focused primarily on knowledge based structures there have also been implications as to the role of external interventions, such as training, learning and so on, in enhancing these knowledge based processes. Thus, incorporated into theories of knowledge based expert performance is the premise that practice mediates and contributes to the efficiency of these (Ericsson and Kintsch, 1995). In other words, those individuals engaging in extensive amounts of practice show superior performance when compared to their counterparts.

In short, it may not be denied that in any aspects of expert performance, such as playing chess, knowledge based domain experience and strategies may play a crucial role. How and in what form these knowledge based structures may exert their influence is still debatable. The manner in which they may be organised together with the role of external factors and strategies are currently some of the issues subject to extensive research. One could therefore safely argue that the issue of knowledge and strategies is indeed important and should inevitably be considered when conducting research into the acquisition of expertise. However, equally plausible is the

argument that for experts in some domains, such as target throwing, knowledge based experience or strategies play little or no crucial role. Hence one may view expert performance in this domain as perhaps being influenced by external factors such as learning and practice. This issue will be dealt with in Chapter 6.

#### **3.3.1.2. The role of environmental factors.**

Contemporary researchers such as Bloom, (1985) and Ericsson, et al., (1993) have moved away from exploring the nature aspects (innate ability) in an attempt to understand expertise in favour of a more environmentalist (nurture) approach.

For example, one environmentalist account put forward by Bloom (1985) suggests that involvement in a particular domain can be distinguished by several different stages of development. Stage 1 is where a child would show an interest in a particular domain which would encourage parents or carers to seek coaching in that domain. During Stage 2 parents or carers provided support to establish regular practice and training habits, sometimes seeking alternative, more qualified coaches and encouraging their children to gradually increase practice. Stage 3 is where optimal training/coaching conditions are sought to provide support in raising their level of performance to an elite level. Bloom (1985) found that nearly all International level performers had worked with a coach or teacher that had previously acquired elite level of performance themselves, or instructed others who had. Therefore during this stage the services of the best available coaches and teachers are sought. Below is a summary of Bloom's work, his findings and how it relates to the current work with elite dart players.

Based on interview data with elite performers, their parents and teachers Bloom (1985) was able to identify a constant progression through several stages of development for International level



performers. He found that future elite performers were typically introduced to their domain of expertise initially under playful conditions as children. At some point during this early exposure the child would show an enthusiastic interest in the activity, often accompanied by promising ability when compared to other children in the same environment. Consequently parents would arrange for instruction by a teacher or coach who was skilled in working with children in this particular domain. During this stage of development there was an active parental role whereby parents would help their children to establish regular practice habits and provide support and positive reinforcement in response to improvement in performance. With further improvements in performance better qualified teachers and coaches were usually sought and the amount of daily practice time slowly increased. The early to mid-teens years proved to be somewhat of a watershed period for many of the children in Bloom's study. During this time future elite performers initiated a major commitment toward achieving top level performance in their domain. Important decisions were made at this point such as seeking out alternative, more appropriate top level teachers or coaches accompanied by optimal training conditions, which in some cases required the family to move to a different area. In several different domains investigated Bloom found that almost all International level performers had worked, at some point during their development, with teachers or coaches that had either been elite performers themselves or had previously instructed students who had attained that level.

In summary, the work of Bloom has provided strong evidence to suggest that, whatever the initial characteristics of an individual (and regardless of giftedness and/or talent), once an interest in a particular domain has been established, there needs to follow a long, intensive process of support, nurturing, teaching, training and encouragement. Only then will an individual have the opportunity to acquire an elite level of performance. Arguably, the

main impact of Bloom's work was to raise questions as to the role of special gifts and innate abilities as a prerequisite of the development of talent.

Ericsson et al., (1993) have focused more on the role of deliberate practice and issues related to the contribution of cognitive psychology as influential in their contribution to the acquisition of expertise. Their paper, 'The Role of Deliberate Practice in the Acquisition of Expert Performance', which was based on interview data with expert musicians, explains expert performance as the end result of an individuals' prolonged efforts to improve performance while negotiating motivational and external constraints (the tenets of which will be discussed in section 6.2.1).

### **3.3.2. The Development of Expertise and the Role of Deliberate Practice.**

Deliberate practice by definition is a term used to describe those activities one would engage in which are designed purely to improve performance in a given domain. Based on a review of a century of laboratory studies of learning and skill acquisition Ericsson et al., (1993) concluded that 'the most effective learning requires a well-defined task with an appropriate difficulty level for the particular individual, informative feedback, and opportunities for repetition and corrections of errors'. When all these elements are present they used the term 'deliberate practice' to characterise training activities. They argue that when these criteria are used to examine many of the areas of expertise investigated in the literature it becomes apparent that most individuals actively participating in a domain spend very little, if any, time engaging in deliberate practice. In fact, the vast majority of time is spent engaged in playful, effortless domain related activities where the primary purpose is enjoyment. When individuals have the opportunity to utilise similar training environments, large individual differences in the level of

performance attained will emerge. Ericsson, et al., (1993) refuted the notion that these differences in performance are evidence for innate differences in ability (e.g., talent), and further claim that experts are not qualitatively different to non-experts. Consequently they made an attempt to identify those training activities that would most likely lead to improved performance. As mentioned previously, their paper, 'The Role of Deliberate Practice in the Acquisition of Expert Performance', which was based on interview data with expert musicians, explains expert performance as the end result of an individual's prolonged efforts to improve performance while negotiating motivational and external constraints. They claim that most people begin a regimen of effortful activities (which they describe as deliberate practice) in their childhood, designed purely to optimise improvement on a particular task. They work within what they describe as the 'monotonic benefits assumption', which basically states that the amount of time an individual is engaged in deliberate practice activities is monotonically related to that individual's acquired performance. Even individual differences within experts can be accounted for within this assumption (namely the amount of deliberate practice). They argue that experts start actively participating in their area of expertise during childhood, a claim supported by Bloom (1985), and this fact makes it virtually impossible to separate innate abilities from experience and deliberate practice.

Ericsson et al., (1993) distinguish three general types of activities, which are domain related: work, play and deliberate practice, moreover, the goals, costs and rewards of these three activities differ, as does the frequency with which individuals pursue them. For example; work includes public performance, competitions, services rendered for pay and other activities directly motivated by external rewards. Play includes activities that have no explicit goal and are inherently enjoyable. Deliberate practice includes activities that have been specifically designed to improve the current level of performance. When applied to an individual, the theoretical

framework of Ericsson et al., (1993) make several predictions concerning developmental histories of experts, current levels of performance, evaluations regarding the nature of deliberate practice and its affect on the level of performance one may acquire. They suggest this framework could be generalised to other domains.

In brief; their first prediction regarding developmental history makes two sub-predictions; first, that past amount of deliberate practice is directly related to an individual's current performance, this they termed the "monotonic benefits assumption" (mentioned previously). However they do emphasise that one must meet all the conditions of deliberate practice (ie. engage in a well-defined task with an appropriate difficulty level for the particular individual, informative feedback, and opportunities for repetition and corrections of errors) to improve one's level of performance. Therefore, improvement is a function of the *quality* and *amount* of deliberate practice, experience alone in a particular domain is not a reliable predictor of improvement unless you engage in the appropriate activities. Second, that expert performance is not reached with less than 10 years of deliberate practice (see section 3.3.2.1 for further information). Also, that deliberate practice starts at low levels and increases slowly over time (Ericsson et al., 1993).

Secondly, predictions about current levels and habits of practice claim that the highest improvement in performance, and indirectly the highest attained performance, is associated with the largest weekly amounts of deliberate practice. Thirdly, their predictions about experts' evaluations regarding the nature and role of deliberate practice activities state that experts would rate deliberate practice very high on relevance for performance, high on effort and comparatively low on inherent enjoyment (see section 3.3.2.2 for further information). Ericsson et al., (1993), argue that deliberate practice is not inherently enjoyable but individuals engage in it as an instrumental means to improve their

performance. In support of this claim they cite studies showing that individuals who gave up their goal to improve their performance in a particular domain soon after reduced their amount of deliberate practice to a level comparable with that of a novice in the same domain.

In short, although there are some contrary findings when individual tenets of Ericsson et al.'s (1993) Theory of Deliberate Practice has been tested across various domains it has nevertheless been influential for two reasons. First, it offers scope for some generality with respect to the acquisition of expertise, which can be used as framework to investigate expertise in a wide range of activities. Secondly, it offers an opposing paradigm to those who propose the 'talent' theory of expertise, whereby high-achieving individuals acquire their outstanding skill with the same, or even less, practice than others.

#### **3.3.2.1. The ten year rule of preparation.**

There is evidence to suggest that peak performance in activities that require physical exertion is typically attained on average 5 years after physical maturation whereas in those activities recognised as non-vigorous peak performance occurs on average 10 years after physical maturation (See Schulz and Curnow, 1988). This discrepancy could imply an important role of preparation (Ericsson, 1996). In fact Chase and Simon (1973) made a more explicit claim regarding the importance of intense preparation stating that chess players required at least 10 years of preparation to acquire International level of performance, moreover they suggested similar prerequisites for other domains. Further research has to some extent substantiated these claims, for example Bloom (1985) found that even for some vigorous sports the ten year rule applied. For reviews, and further research findings in support of this phenomenon, see Ericsson,

(1996). The true meaning of the ten year rule has occasionally been misinterpreted as meaning ten years “experience” in a domain as being enough to acquire expert performance which is not the case. As mentioned previously, experience alone is a weak predictor of the level of performance an individual may acquire the emphasis here is on the role of preparation rather than experience. Preparation in this case meaning the time one spends, engaging in, those activities designed purely to improve performance and eventually attain expert levels of performance. The importance of structured preparation can be inferred from the gradual increases in performance as a function of the number of years of instruction and serious study reported in several domains (see Ericsson et al., 1993).

#### **3.3.2.2. Effort and deliberate practice.**

Ericsson et al., (1993) argue that the limited time duration in which individuals are able to practice effectively provides the best evidence for the effort it requires. They provide evidence to show that the duration of effective daily practice is limited as, according to "teachers and training instructors it is necessary to maintain full attention during the entire period of deliberate practice" Ericsson et al., (1993. p. 370). They draw on previous research from the domain of music by Auer (1921) and swimming by Chambliss (1988) cited in Ericsson et al., (1993) who state that mental concentration is a most crucial aspect of effective practice. So much so that without concentration practice can even be detrimental to performance, therefore when concentration starts to wane the individual should stop practising and rest. Moreover, both Auer (1921) and Seashore (1939), cited in Ericsson et al., (1993), also from the music domain, recommend that practice sessions be limited to less than one hour with ample rest in between. In their study 1 with violinists Ericsson et al., (1993) looked at the relevance of practice related activities, the effort they required and if they were pleasurable to the participants. But they did

not differentiate between physical effort and mental concentration for training activities, a point picked up on by Starkes, et al., (1996) who also found that mental concentration is the most essential aspect of deliberate practice.

### **3.3.2.3. Starting age, accumulated practice and performance.**

Ericsson et al., (1993) also looked at the relation between starting age and performance, the idea being that individuals who started participating in an activity at an earlier age would have engaged in more deliberate practice. Moreover, they claim there is evidence to suggest that across a wide range of domains the commencement of weekly amounts of practice will be small but slowly increase over a period of time to maximal levels. When generalising across particular domains of expertise Ericsson et al., (1993) suggest that in sport the time at which an individual first engages in the activity is much less closely linked to the start of deliberate practice than for musicians for example. The mean age at which Ericsson et al.'s (1993) subjects in study one (4 x groups of violinists) starting playing the violin was 7.9 years old which coincided with the age at which they first started systematic lessons, i.e., 8.0 years old (Ericsson et al., 1993). Moreover, the relationship between age and amounts of weekly practice is strong for musicians and Ericsson et al., (1993) suggest this is due to maturational factors. However, Starkes et al., (1996) found a strong relationship between increase in practice and length of engagement for sports where the starting age was much older. It has also been argued that such increases in the amount of daily practice could "reflect slow adaptations to the demands of concentration during practice that are relatively independent of age" (Ericsson, 1996, p. 24). Helsen et al., (1998) conducted two studies. In their first study they investigated three groups of male soccer players, International players (n = 17) mean age 25.6 years, national players (n = 21)

mean age 24.0 years and provincial players ( $n = 35$ ) mean age 25.4 years. They found that all groups began playing soccer at mean age of 5.5 years and started engaging in team practice at 7.1 years. Both International and national level players reached their peak in accumulated number of hours of practice (individual and team) at 15 years into their career i.e., at 20 years of age. The mean number of hours per week spent in practice for the International level players was 13.3 hours plus or minus 2.5 hours and for the national level players was 9.9 hours plus or minus 1.9 hours. In contrast Provincial level players reached their peak in accumulated number of hours of practice (individual and team) at 6 years into their careers i.e., age 11 years of age, with a mean number of hours per week of 6.9 hours plus or minus 2.2 hours.

In their second study Helsen, et al., (1998) included three groups of male field hockey players, International ( $n = 16$ ) mean age 25.9 years, national players ( $n = 18$ ) mean age 24.4 years and provincial players ( $n = 17$ ) mean age 25.2 years. All groups began playing field hockey at a similar mean age of 8.6 years plus or minus 0.6 year and started engaging in team practice at approximately the same time mean 8.7 years plus or minus 0.6 years. Both International and national level players reached their peak in accumulated number of hours of practice (individual and team) at 18 and 12 years into their career respectively. International players were then approximately 27 years of age and national players were approximately 21 years of age. The mean number of hours per week spent in practice for the International level players was 19.1 hours plus or minus 5.1 hours and for the national level players was 12.9 hours plus or minus 6.9 hours. Provincial level players reached their peak in accumulated number of hours of practice (individual and team) at 9 years into their careers i.e., age 18 years of age, with a mean number of hours per week of 8.1 hours plus or minus 5.4 hours.



Hodges and Starkes (1996) completed a sport specific test of Ericsson et al.'s (1993) Theory of Deliberate Practice. Study 1 investigated four groups of male amateur wrestlers ( $n = 42$ ). Two of the groups were current wrestlers and two groups had retired from competitive wrestling. The current age of the four groups was as follows; International-current mean age of 24.1 years plus or minus 1.9 years, club-current mean age of 24.8 years plus or minus 3.2 years, International-retired mean age of 38.2 years plus or minus 5.1 years and club retired 35.9 years plus or minus 8.5 years. All four groups started wrestling at a similar time i.e., mean age of 13.2 years plus or minus 0.6 years and engaged in systematic practice on average 1 year after starting. Both groups of retired wrestlers reported reaching their peak at a mean of 25.1 years plus or minus 0.7 years. The average time difference between the start of wrestling and the peak of their careers was 11.4 years. Study 2 investigated 10 male members of the Canadian national amateur wrestling team (9 of which had been participants in the first study) and 11 male McMaster University club wrestlers (4 of which had been participants in study 1). The mean age of International wrestlers was 25.1 years plus or minus 2.4 years and the mean age of the club wrestlers was 23.09 years plus or minus 3.4 years.

Overall these studies (Hodges and Starkes, 1996; Helsen et al., 1998) found that starting ages were similar across levels of skill within each sport investigated. Although there were differences across groups in amount of practice, this was not a function of starting age as Ericsson, et al., (1993) have previously suggested.

### **3.4. From genes to supremes : The Singer - Janelle's account.**

Finally, in a more recent study, Singer and Janelle (1999) examined and critically evaluated our current understanding of how expertise is developed. They did this by drawing on contemporary literature dealing with hereditary and genetic accounts, the influence and potential value of practice, necessary environmental conditions, and the potential interactions of these influences on motor performance. Specifically addressed are hereditary accounts of overall health and well-being, physical attributes, personality characteristics, information processing capabilities, and intelligence. With respect to the role of practice a particular mission was to focus on recent research dealing with the quality of the practice setting, rather than debating the duration needed to achieve expertise. In this respect, the roles of self regulation and competitive simulation are discussed. Finally, current ideas surrounding the potential that environmental influences have in aiding genetic potential and practice capabilities of aspiring athletes to come to fruition are described. Conclusions are offered suggesting that to advance our understanding of expert performance beyond its current status, proponents focused on polar ends of the nature-nurture continuum must adopt a less confrontational, more integrative approach in future research endeavours.

In short there appears to be convincing evidence that deliberate practice *per se* may be a contributing factor in the development of expertise in a variety of domains. Whilst Ericsson et al., (1993) acknowledge issues such as strategies and talents they nevertheless place a much greater emphasis on the role of deliberate practice and the ten year rule of preparation necessary for developing skill to an expert level. Such considerations are of course important when evaluating expert performance. They offer the possibilities that differences between experts and novices, and those labelled as gifted, talented and superior as opposed to the “normal” population, may come about as a result of one's deliberate

actions towards gaining excellence rather than the kindness of natures' selection processes. Bearing in mind the aim of this thesis is related to expertise in sport, the next section is aimed at highlighting contemporary research in this area. Moreover, the contribution such research has made regarding factors affecting the acquisition of expertise not only in sports with obvious mental components (e.g. Chess), but also those based more on excellence in physical and perceptual motor skills (e.g. boxing and dart playing). This issue will be addressed in the next section.

### **3.5. The classification of sports and its implication for studying the acquisition of expertise.**

Each and every sporting activity is a unique entity. There are numerous sporting dichotomies that one could build based solely on the contribution of those requiring physical as opposed to mental attributes, for example from weightlifting to chess and so on. One is also forced to consider the element of strategies. Chess for example being heavily based on the type of strategies an individual may adopt whereas, in contrast, target throwing and dart playing which incorporates little, or no, strategic components. Of course, there are further classifications that one could make regarding sporting behaviour. For example, whether interactive teamwork is an essential factor, as in football, or not, as in team dart playing. Arguably, as a consequence it may be useful to view sporting activities as alongside a continuum on which sports are classified according to the contribution each component is expected to make to overall performance. This could range from those sports where physical strength is crucial (e.g. weightlifting) to those “sports” requiring specific cognitive strategies (e.g. chess). Along this continuum one could also find sports that are noticeably dependent on a combination of both physical and cognitive factors with the extent of reliance varying as one moves to either side of the pole. For example,

boxing may require extensive physical strength together with a degree of cognitive strategies for accurate punching, whilst snooker may benefit more from superior cognitive strategies as well as some level of physical technique. Once the components that are crucial to performance in a particular sport have been identified then one could investigate these components in a more isolated fashion. This may lead researchers to discover how individuals acquire expertise in specific components of one particular sport that could be applicable to an alternative sport.

As mentioned earlier in certain sports physical strength may be argued to play a major role in the level of expertise that one may require (e.g. weightlifting). In this respect it is common knowledge that aspiring athletes need to engage in rigorous training programs to reach optimal levels of physical strength/performance. Recent research has shown that, with the exception of height, most physical attributes (e.g. aerobic endurance, size of heart and lungs, flexibility of joints and strength of bones,) can change dramatically in the course of intense physical training (see Ericsson, et al., (1993) for a review). Arguably then, given the right circumstances one should be able to increase levels of performance in a particular domain for which physical strength plays a major role, through intensive organised training and motivation (Bloom, 1985). But in contrast to sports where physical training is essential to performance there are certain sports where, one may argue, to reach a level of expertise physical strength "per se" may play a minimal role (e.g. Chess).

Thus, in accordance with classifications of sport along the continuum of knowledge based attributes to physical and perceptual attributes, a reasonably fruitful tactic for past researchers has been to compare the strategies of experts with novices within a specific domain in order to discover the mechanisms that underpin expert performance. Indeed the work of deGroot (1946/78) which was detailed in an earlier section of this Chapter is one such attempt. The

demonstration that world class chess players (experts) are distinguished from local chess club players (novices) by their superior cognitive abilities in only a chess playing context was indeed a groundbreaking discovery. Thus, providing inspiration for the comparison of performance levels between experts and novices which has since been used extensively by researchers in several different sports. Thomas and Thomas (1994) also used a cognitive approach when investigating expert/novice differences in various types of knowledge. They investigated declarative knowledge (factual information such as history, knowledge of player status, current organisation and rules), procedural knowledge (the ability to generate action, namely how to do something) and strategic knowledge (knowing how to use information), within a specific domain and examining the effects of their interaction. They also claim that experts exhibit similar knowledge regardless of age or area of expertise. For future research they emphasise the importance of separating knowledge, skill and game performance, that studies must clearly identify experts and should ideally be applicable to real world situations. This topic will be dealt with next.

#### **3.5.1. Expert - novice differences in several sporting domains.**

Abernethy (1988) investigated the perceptual strategies of 12 expert and 15 novice badminton players. They found that experts were superior at making predictions than novices. This finding has also been supported in field hockey (Starkes, 1987) who further claims this is due to extensive practice. McPherson and Thomas (1989) found that tennis experts had higher skill levels, more knowledge and better game performance at all ages, than their novice counterparts who although in some cases had a high level of knowledge did not possess adequate skill to execute the knowledge. Abernethy et al., (1994) investigated visual-perceptual differences between expert, intermediate and novice snooker players by visually presenting them with slides

depicting game situations and slides depicting balls positioned randomly. They found that experts had superior ability to recognise game situations but were no better than novices at recognising information when the balls were randomly presented. Helsen, et al., (1998) conducted two studies examining three levels of skill across adult male soccer players and adult male field hockey players. As well as investigating starting age and accumulated number of hours practice for all six groups (findings of which are cited in section 6.2.2.) they also looked at team versus individual practice. They reported 'rather limited' differences in individual practice between skill levels among soccer players with a significant decrease in individual practice for the International level group between the age 12 to 15 years. There was a significant difference, across all levels of skill, for team practice from 12 years of age onwards into their career. Overall there was an observable shift from individual to team practice with increasing age. For the field hockey players those at International level reported spending more time engaging in individual practice activities when compared to those players at both national and provincial level. However, contrary to Ericsson et al.'s (1993) theory of deliberate practice both International and national level players spent more time engaging in individual practice than provincial level players. There are several important implications in relation to the findings of Helsen et al., (1998); First, the 'Ten Year Rule' first proposed by Simon and Chase (1973) cited in Ericsson et al., (1993) was supported for both soccer players and field hockey players. Secondly, results showed a monotonic relationship between the amount of deliberate practice (both individual and team) and the eventual performance level attained. Moreover, the monotonic relationship with level of skill is consistent regardless of the age at which the activity is started. Thirdly, it was found that International performers have the highest reliability estimates of recall. The authors suggest this is probably due to one of two reasons; either practice has played such an important role in their lives that it is readily recalled or because practice consumes such a great deal of their everyday life that all other activities must be

scheduled around it. This leads to an extremely organised routine and, as a consequence, practice times are readily recalled. This phenomenon has been reported by Pedhazur and Schmelkin (1991) who found that athletes have exceptional confidence in their own ability to recall practice activities, more so than other sport-related or everyday activities. Finally, Helsen et al., (1998) suggested that, if the Theory of Deliberate Practice is to be applied to sporting domains in a meaningful way, then clear definitions must be incorporated within the theory to differentiate between individual and team practice. They propose that it becomes more noticeable with increasing research findings that what constitutes deliberate practice is in fact different across domains.

A further comparison of expert versus novice data was reported by Hodges and Starkes (1996), (also cited in section 3.3.2.3), when completing a sport specific test of Ericsson et al.'s (1993) Theory of Deliberate Practice with groups of wrestlers, differentiated by skill (International/club) and current status, i.e., retired or active. As well as investigating starting age and accumulated number of hours practice across all groups (findings of which are cited in section 6.2.2) they also looked at wrestlers evaluations of wrestling-related activities and everyday activities and their contribution to wrestling performance. At 6 years into their careers the International wrestlers began to differ with regard to the amount of time they spent in wrestling-related activities (International = mean of 38.7 hours per week, Club = mean 28.4 hours per week). In order to determine which specific activities accounted for these emerging differences data were analysed separately for practice alone and practice with others. Practice alone yielded no significant differences between groups, therefore practice with others was found to be the differentiating factor. Subjects were further required to evaluate activities according to their relevance for improving performance, effort, enjoyment and concentration. Briefly, what was interesting here, was

those activities rated as most relevant for improving performance were also rated as most enjoyable. This is in contrast to the proposal of Ericsson et al's (1993) Theory of Deliberate Practice which claims that 'practice is not inherently enjoyable' (Ericsson et al., (1993). p. 372). Overall Hodges and Starkes (1996) found that the wrestlers 'retrospective estimates provide quite substantial support for a theory of expertise based on practice time with others' (p. 420), but 'with regards to support for a theory of expertise based solely on "deliberate practice" the answer is still unclear' (p. 421). Arguably, two important findings to emerge from this research were, first, the time difference between the starting age and peak performance of the retired wrestlers was greater than 10 years which is consistent with previous literature. Secondly, the importance of differentiating effort as a separate factor from concentration. Ericsson et al., (1993) looked at the relevance of practice related activities, the effort they required and if they were pleasurable to the participants but they did not differentiate between physical effort and mental concentration for training activities. This is indeed an important issue as Starkes et al., (1996). found mental concentration as being the most essential aspect of deliberate practice.

Hodge and Deakin, (1998) employed participants from the martial arts to examine the influence of context in the acquisition of novel motor sequences and the applicability of Ericsson et al.'s (1993) theory of deliberate practice to this sport. Two groups (expert and novice) of 10 students who were current participants in the Martial Arts Canada program (Chikarajitsu) took part in the study. The expert group had a mean age of 18.4 years with approximately 6.9 years experience whilst the novice group had a mean age of 17.4 years with approximately 1.2 years experience of karate. The presence of context did not benefit recall performance for the experts, and the performance of the novice group was hindered by the presence of context. Evaluation of the role of deliberate practice in expert performance was assessed through retrospective questionnaires.



The findings related to the relationship between relevance and effort, and relevance and enjoyment diverged from the Ericsson et al., (1993) definition of deliberate practice, suggesting that adaptations should be made if it is to be considered a general theory of expertise.

Lidor, Argov and Daniel, (1998) examined perceptual motor differences between 13 skilled and 10 novice female handball team players. Subjects completed two laboratory activities (to measure anticipation time, reaction time and movement time) and three field tasks (to measure accuracy and speed of throwing abilities). Reaction time and movement time were collected during a unique team handball motor activity. Analysis by way of ANOVA with repeated measures on trial blocks indicated high mean proficiency for the skilled participants in reaction time and all field-throwing tests compared with novice subjects. Skilled subjects threw faster and more accurately and responded more rapidly than their novice counterparts. These differences further support superiority in sport settings gained by physical achievements and psychomotor excellence.

Werner and Thies (2000), addressed the question of whether individual characteristics of the observer, namely expertise in a domain, selectively influenced the ability to detect changes in images from that domain. A total of 48 individuals, half of whom were experts in the sport of American football (mean age 27.8 years) and half of whom were American football novices (mean age 24.2 years), were presented with alternating sequences of football-related and unrelated images. The search time it took subjects to find the change between the two images was measured. Subjects indicated verbally when they had found the change and the appropriate time was noted. Subjects then named the change. If no change was detected after 40 sec. the sequence ended and the trial was scored as unsuccessful. This constituted the second dependent variable (unsuccessful searches). On unsuccessful trials, the change was demonstrated to the

subject by replaying the final part of the sequence and pointing it out. Results indicate that expertise in a specific domain increases observers' sensitivity to semantic changes of domain-related images.

### **3.6. Expert - novice differences and age - related performance.**

Starkes, Weir, Singh, Hodges, and Kerr (1999) argued that expertise in sport deteriorates after peak performance and is susceptible to both cognitive and physiological aspects of ageing. Two studies examined the relationship between age and running times in the 200, 400, 800 and 5,000 meter track events, to determine whether age related decreases in performance are best represented as a linear or quadratic (rapidly increasing) relationship. Study 1 described the career training patterns of 40 male Master athletes (aged 35-85 years) who competed at the 1998 Canadian Masters Athletics Association championship. These athletes had trained and competed for over 20 years and continue to train approximately 6.5 hours per week. Their practice sessions consist primarily of speed, power and endurance training and they continue to perform at relatively high levels. A relationship of performance decrement and age in the 200 metres were purely linear. Study 2 plotted the age and performance times in the same events for over 500 competitors around the world. These cross-sectional data showed rapid declines in performance (a quadratic relationship with age) particularly after age 60. Implications for expertise research and "age-grading" of performance are discussed.

Ripoll and Benguigui, (1999) argued that a large part of expertise in fast ball sports develops during childhood. In particular that expertise is the result of the interaction between maturational factors and experiential factors. Williams and Grant (1999) considered whether there are any potential training methods to enhance the development of perceptual skill in sport.

They argued that improvements in perceptual skill transfer to the performance context and sport-specific training programs, which develop the knowledge base underlying skilled perception, are likely to be more effective than clinically-based visual skills training programs.

### **3.6.1. Expert - novice differences and cognition.**

Helsen and Starkes, (1999) reported three experiments examining the relative importance of attributes determined largely by the efficiency of the visual/central nervous system versus cognitive domain-specific skills, in the determination of expertise in soccer. In their first experiment 28 expert and intermediate male soccer players were assessed on various non-specific abilities including processing (simple reaction time, peripheral reaction time, visual correction time), optometric (static, dynamic, and mesopic acuity), and parametric parameters (horizontal and vertical peripheral range). In their second experiment domain-specific variables were assessed including complex decision speed and accuracy, number of visual fixations, fixation duration, and fixation location in solving game problems. Stimuli were initially presented by slides and, in a later experiment by 16 mm film (experiment 3). Eye movements were recorded and analysed. A stepwise discriminate analysis of both non-specific abilities and soccer-specific skills revealed an average squared canonical correlation = 0.84, with the significant step variables all being domain-specific skills.

Finally Toward, (1997) sought to examine expert-novice differences in metacognitive knowledge and metacognitive skill functioning, as they relate to the performance of the basketball foul shot. Twenty-four female undergraduate students took part in this investigation. Half of the subjects were classified as basketball experts (group one) and half as basketball novices (group two). Classification as either an expert or novice was dependent upon the total

number of seasons having played competitive basketball. Both groups of subjects performed three tasks, each designed to assess a different aspect of their metacognitive functioning. Task one sought to identify group differences in the declarative component of metacognitive knowledge about action through the collection and comparison of instructional verbal protocols. Task two sought to identify both between group differences and the within group relationship between one's actions and the corresponding verbal description of those actions through the collection and comparison of verbal and visual protocols. It was believed that such a comparison would serve to identify group differences in the procedural component of metacognitive knowledge about action. Finally, task three sought to identify group differences in metacognitive skill functioning as determined through each subject's ability to monitor her performance, predict performance outcomes, and explain the predictions made. When combined, the results obtained from these three tasks suggested that, specific to performance of the basketball foul shot, the level of metacognitive knowledge with regards to action and metacognitive skill possessed by the subject within this investigation was a function of their level of expertise. The 'expert' subjects within group one were seen to provide complete and accurate instruction in the proper execution of a basketball foul shot. Their ability to accurately describe the actions produced at task two indicated they possessed higher levels of the procedural component of metacognitive knowledge about action when compared to group two subjects. Group one subjects were seen to make significantly more foul shots than group two subjects at task three and were also significantly better than group two subjects with respect to their ability to monitor and successfully predict their performance outcomes. The results obtained from this investigation served to highlight the important, yet often overlooked, association between action and cognition.

In short, there is much evidence provided from the aforementioned literature that the expert novice paradigm, as a means of studying the acquisition of expert performance, is indeed a useful tool. Moreover, when applied in a sports setting, one may argue that this paradigm is equally effective regardless of the nature of the activity, i.e., predominantly physical sports versus predominantly cognitive sports. In almost every instance quantitative differences between experts and novices in a particular domain have been reported. Thus, allowing researchers to focus on factors that are crucial to the development, acquisition and maintenance of expertise whilst being able to eliminate those less crucial factors.

### **3.7. Methodological considerations.**

Much of what has been reported in this chapter was intended to highlight how expertise has been studied from various theoretical standpoints using paradigms ranging from retrospective explanations to experimental laboratory based work. Questions that could be raised here are first, whether a particular method of investigation is more fruitful in research of this nature e.g. the comparison of experts versus novices in experimental tasks or via qualitative methods such as interviews, or a mixture of both? Secondly, could the effectiveness of the chosen method of investigation be sport specific? Finally, what exactly is being measured when the term “measuring” expert performance is used; the specific composite individual skills required or overall performance?

Ericsson (1996) suggests there should be three criteria in place to enable researchers to investigate expertise in a scientific manner. First, that “expert behaviour has distinctive observable characteristics and that it occurs reliably in clearly specified situations (characteristics of expert behaviour)”. Secondly, that “experts are able to reproduce the

behaviour under controlled conditions to allow for experimental variation and systematic observation of the mediating processes (reproducibility in the laboratory)". Finally, the "behaviour should be predictable and describable by objective absolute measurements (measurement in absolute terms)". For example in a sporting context this could be by units of time (i.e., 100 meters dash, 1500 meters), by subjective scores on a set scale (i.e., gymnastics, ice skating) or by concrete measuring systems such as units of distance (javelin, discus), units of height ( high jump, pole vault) or absolute scores (snooker, darts). In essence, expert performance should be measured by absolute standards that are independent of social and historical context.

In terms of reproducible behaviour Ericsson (1996) proposes that an "expert" should have the ability to reproduce expert performance at a time determined by external factors. An expert's control over the production of expert performance suggests they are able to reproduce the performance outside of its usual context under controlled laboratory conditions. In individual sport, where the conditions of competition are standardised, in many instances it is not problematic to test experts under laboratory conditions. However, in many other sporting domains the representative situations encountered by experts cannot be recaptured in controlled laboratory conditions due to the necessary interactive nature of the tasks, which often involve other experts and/or participants. (For a review of the literature see Patel, Kaufman and Magder. 1996). The methodology proposed by Patel et al., (1996) for investigating individual experts within an interactive situation requires that one first identifies particular goal-directed activities of an individual in the interaction. Then the relevant context of this activity and its goal can be converted into a standardised task and tested under laboratory conditions. By identifying the interactive interchange and reproducing it as a single component or sequence of components well-defined tasks can be presented to expert performers in the same domain and comparisons

can be made. This methodology has been successfully applied when investigating the performance of expert and novice chess players (de Groot 1946/1978; Charness, 1991). It has also been extended to the analysis of expert performance within an interactive team context in sport (Helsen and Pauwels, 1993). Finally Ericsson's definition of *absolute measures of expert performance* is based upon a hierarchical organisation within a social context. Even for expertise in sport, where performance is measured objectively, evaluation is primarily relative whereby the individual producing the best performance on a given day, in a given competition, is considered the winner. Experts are, on certain occasions, judged by ranking lists based on a points or monetary system. Moreover, the level of a performer is usually described by the appropriate standard of competitions entered, namely, club, county, national and International. The number of competitors engaging in a sporting activity is strongly associated with the standard of competition, for example; there may be several competitors at club level but as the standard increases the individuals competing at that standard decreases i.e., in most sports there is only one world champion. Relative standards of performance are recognised at each level which ensures the maintenance of a hierarchical structure, but levels of performance and consequently recognised standards at each level are dynamic whereby the level of performance can increase (and less often decrease) over time.

To summarise; When there are well established best responses in a particular domain of expertise, performance can be represented and measured by a set of standardised tasks. Once expert performance can be reliably reproduced under controlled laboratory conditions its mediating mechanisms can be described and identified by process-tracing methods along with more traditional methods of investigation.

### **3.8. Dart playing as a medium in the study of expertise in sport.**

Darts is a non-contact target sport with universal playing rules incorporating a clear cut, unambiguous scoring system that lends itself to the systematic exploration of factors that may contribute to expert performance. The playing environment is static and consistent for all competitors, the match format and equipment are all governed by strict, universally enforced rules. All Championship dartboards are of a 1-20 clock pattern (see appendix 3 for example of dartboard). An inner narrow band scores a 'treble' of the segment number, an outer narrow band scores a 'double' of the segment number, an outer centre ring scores '25' and an inner centre ring scores '50' (known colloquially as the bullseye). The throwing distance for all players is 7' 9 ¼" (2.37m) from the face of the board to the back of the oche. The height of the board is 5' 8" (1.73m) from the centre of the 'bullseye' to the floor (see appendix 4 for example of throwing dimensions).

Championship matches are played over a pre-designated number of legs, each leg starts at 501 points and must be finished on a double segment. Each player throws in turn and deducts each score thrown until they have completed 501. The aim is to complete each leg before your opponent, ie, by hitting the winning double first. Although every double counts as a finish analysis has shown that certain finishes are more popular than others (Brown, 1981). For example, it is favourable to leave even numbered doubles as opposed to odd numbered doubles because should one miss it is still possible to throw immediately at an alternative double. Moreover on the basis of this 'rule' doubles such as 16 and 20 are the most favourable as they offer a higher percentage of darts at a double. For example; should one miss double 16 there are still several available options to aim for, namely, double 8, then double 4, double 2, and eventually down to double 1. Because of this, different strategies may be used in the latter part of the leg to 'set up' a particular finish. This represents a cognitive component whereby players will employ different strategies i.e..



throwing at particular segments of the dartboard to finish the match. Moreover, one may finish on a number as high as 170 (3 dart finish) or as low as 2 (1 dart finish), consequently there are several thousand combinations of possible finishes to utilise. Moreover, finishing combinations can change mid throw if a specific target is missed therefore strategies need to be flexible. Due to there being favouritism toward particular doubles strategies are used whilst scoring during the latter part of a leg to ensure that a favoured double is left.

In addition to recording wins and losses, level of performance can be measured using the single dart average which is calculated by dividing the original number of points required to complete a leg by the number of darts used by a player to complete the leg. For example, if a player takes 15 darts to complete a leg of 501 ( $501/15$ ) the single dart average equals 33.40. Alternatively, if a player takes 16 darts to complete a leg of 501 their single dart average would be 31.31 which is less than 33.40. Due to the nature of the scoring system one can reliably assume that superior players will record a higher single dart average.

### **3.8.1. Characteristics of expert performance in darts.**

There are two measures of performance in dart playing. First, the key measure of expert dart performance is the single dart average ( as explained in section 3.8). Secondly, in tournament play, where matches are played on a 'knock out' basis, the key measure of success is the number of matches won regardless of the single dart average. Therefore performance during a tournament is judged primarily on the number of matches won rather than the measure of expert performance, ie; single dart average. Moreover, the higher the level of tournament, i.e., World level, the higher the single dart average required to win when compared to a lower level tournament, i.e., regional level.

### 3.9. Chapter summary.

The main theme of this chapter was to highlight factors that may contribute to the acquisition of expertise in particular domain, with a special focus on expertise in sporting skills. The “traditional” nature versus nurture debate, in relation to factors that may affect ones’ ability to achieve expertise, were reviewed. However, what was also found to be a salient line of debate in the acquisition of expertise came from the emergence of cognitive psychology. For example, the visualisation that humans operate *as if* they are a system for processing information and, thus, to understand human behaviour one needs to understand how the information processing system functions. Indeed, a crude description of the information processing system is explained by one of two distinctive components: a “mechanistic” component which enables the processing of information e.g. the existence of a well established memory system, and a “strategic” component, that is the “master mind” of the processes. Perhaps the nature versus nurture debate finds sufficient room to manoeuvre in debating the significance of strategic (nature) as opposed to environmental (nurture) factors in the development of expertise. The work of Charness (1976), when studying performance of Chess players of various levels of skill, captured the essence of cognitive psychology and showed its relevance, in certain contexts, to the study of expertise. This work, however, was mainly aimed at testing models of cognitive processing, nevertheless it established its roots as pioneering work on the development of expertise in a “sporting” context. Indeed, the game of Chess being a more 'mental' than a 'physically' based sporting activity, provided a perfect example of a sport situated at the extreme end of a continuum of sporting classifications. Assuming such a classification was based on the dimension of the extent to which strategic, as opposed to physical/mechanistic, factors may play a role in performance. It was argued in this chapter that, if one desires an understanding of the extent to which expertise in a particular sport

relies upon the consideration of a cognitive approach, one has to undertake the daunting task of unravelling the distinct contributions of strategic, as opposed to non-strategic factors. The sport of darts, with arguably no strategic component, could be more appropriately situated toward the opposite end of the sporting continuum to Chess. The latter position of darts on the sporting continuum, together with the absence of any systematic research on professional dart players of various levels of skill, was also highlighted in this chapter as being the main rationale behind conducting the experimental and quasi experimental studies reported in the following chapters.

## **Chapter 4: Rationale for Experiments 1, 1a and 2.**

### **4.1. Preface.**

As noted in Chapter 2 of this thesis there is a general consensus that men are overwhelmingly more accurate than women in tasks involving target throwing (Wickstrom, 1977; Lunn and Kimura, 1989). Of the studies reported one of the most recent and perhaps more relevant to the aims and purposes of the current research is that of Watson and Kimura (1991). However, most importantly, is the fact that none of the previous research on gender and target throwing has focused on a unique population of elite men and women who have made a deliberate “life long” attempt to perfect their target throwing skills. Would male supremacy still prevail for this population, if so, to what extent?

Returning to Watson and Kimura (1991) they investigated target directed motor tasks to examine if men and women may employ a similar or separate type of spatial function to those used in more traditionally-measured spatial abilities. For example, they point out that generally males excel on psychometric tests of spatial ability whereas females have an advantage over males on tests of verbal fluency. Females also excel on tests of fine motor control such as assembling small components. In a previous study, investigating hand preference under varying task constraints, Watson and Kimura (1989) reported significant sex differences on two target directed motor tasks; dart throwing and projectile interception. Males were significantly more accurate than females with either hand on both tasks, moreover, these differences did not appear to be an artefact of differences in physique or athletic experience. Watson and Kimura further argued that superiority reported for males on these motor tasks might be related to the already acknowledged male superiority for spatial processing, particularly as both tasks required accurate localisation of a point in space. Watson and

Kimura's findings are based on research conducted with naïve participants, i.e., undergraduate college students, but would the same male superiority be found with a unique population of men and women who had deliberately aimed at perfecting their target throwing ability? Furthermore, would gender differences in target throwing ability exist if participants from the same population were asked to complete throwing tasks with their non-preferred hand? If a significant main effect for gender is reported this would strengthen the previously reported literature namely; that male superiority in throwing exists at all levels of skill. However, two findings would be of particular interest; First, whether women classed as superior do better than men at a lower level of skill. This finding would suggest that women could indeed perform better than men in throwing, possibly due to extensive training. Secondly, if male superiority is eliminated when using their non-preferred hand this has important implications for the role of practice as opposed to biologically based factors.

## **4.2. Experiments 1 and 1a: The extent of gender differences among naïve participants and elite dart players in target throwing skills.**

In the first instance Experiment 1 was conducted using male and female undergraduate university students. The reason for Experiment 1 using undergraduate university students as participants, was to replicate the popularly held view of gender differences in throwing skills using the same setting and materials to be used in the main Experiments (Experiments 1a and 2). This would strengthen the arguments for extending the present findings and linking them with previous research on undergraduate university students. The aim of Experiment 1a was to investigate the extent of gender differences in target throwing among an elite group of dart players representing two levels of skill namely: International/professional level and intermediate/county level. Previous research by Watson and Kimura (1991) with naïve subjects, i.e. college students found that men significantly outperformed women in a dart throwing task. The hypotheses for both experiments were as follows;- for Experiment 1 it was hypothesised that men would significantly outperform women in target throwing accuracy. For Experiment 1a it was hypothesised that men would significantly outperform women in target throwing accuracy and there would be a significant within group effect due to level of skill with International/professional level players outperforming intermediate/county level players. However, it was not clear as to whether there might also be a significant interaction effect in Experiment 1a. Specifically, would International/professional women score significantly better than Intermediate/county men? In addition to engaging in target throwing tasks participants in both experiments completed a short questionnaire providing demographic information and task-related opinions (see appendices 1 and 2 for a copy of each questionnaire).

### **4.2.1. Method Experiment 1.**

#### *Design*

The independent variable in Experiment 1 was gender, with two levels. The dependent variable was throwing accuracy measured in millimetres (mm), with the lower scores being more accurate than higher scores. The experimental hypothesis was that men would be significantly more accurate than women.

#### *Participants*

Participants were 20 male (mean age = 22.75yrs, SD = 1.74) and 20 female (mean age = 22.65yrs, SD = 4.32) right handed undergraduate university students.

#### *Materials/Apparatus*

*Questionnaire.* Each participant was asked to respond to questions from a 10 item questionnaire which was completed by an assistant to the author (see appendix 1 for a copy of the questionnaire). The questionnaire provided demographic information, such as age, gender, as well as responses to task-related opinions such as ‘ How difficult do you think the task of target shooting will be?’ and post trial ‘Now rate how difficult the task of target shooting was?’ The responses to the questionnaire were recorded by both choice alternatives and on a 1 to 7 Likert type scale, where 1 = very difficult and 7 = very easy. The apparatus used was a standard match-play dartboard with a plain surface having only the bullseye depicted as the target area (see appendix 5 for diagram of apparatus). For the purpose of recording the accuracy of each dart a circular piece of light card 194mm in diameter, matched in colour with the surface area of the dartboard, was secured over the centre of the dartboard. A hole was cut out of the card at the centre, which was placed over the bullseye (target area) on the face of the board. Due to this, any dart that reached its

target would not mark the card and would be recorded as a 'hit'. Each participant used the same set of 24 gram nickel tungsten darts supplied by the experimenter.

### *Procedure*

Participants were tested in one session in an isolated area where a dartboard was available specifically for conducting the throwing tasks. Prior to conducting the throwing tasks each participant was asked to respond to questions on the questionnaire which was completed by a research assistant. On completion, participants were instructed to throw 12 darts at the target. The landing point of each of the 12 darts was recorded by one of three methods according to accuracy; 1) piercing the card surrounding the target, 2) hitting the bullseye or 3) missing the card completely. Accuracy was recorded by measuring the distance of each point of contact, with the card, away from the perimeter of the bullseye in millimetres. Each bullseye was recorded as zero and each complete miss was recorded as 100mm. The cumulative total for each of the 12 darts thrown was recorded as the total for each participant, i.e., the more accurate the player the lower the cumulative score. On completion of the throwing task participants were asked to rate how difficult it was.



**4.2.2. Results and Discussion: Experiment 1.**

Mean scores recorded in millimetres (mm) were calculated for both men and women participants for each experimental condition and are reported in Table 4.2.2.1.

**Table 4.2.2.1. Mean accuracy score (measured in millimetres) and corresponding standard deviations for men and women undergraduate students (the lower score = higher accuracy).**

Men			Women		
Count	Mean	SD	Count	Mean	SD
20	807.20	113.96	20	970.95	103.67

As can be seen in Table 4.2.2.1 there is a 163.75 mm difference in accuracy in favour of men over women, with a low score being more accurate than a high score. Formal analysis of the data was conducted employing a one-way repeated measures ANOVA which found a significant difference in accuracy in favour of men  $F(1,38) = 22.59, p < 0.001$ . These results support previous research by Watson and Kimura (1991) with naïve subjects, i.e. college students, which found that men significantly outperformed women in a dart throwing task. Formal analysis of the data found significant differences in favour of men for confidence in performing the task  $F(1,38) = 40.07, p < 0.001$  and perception of task difficulty  $F(1,38) = 17.53, p < 0.001$  with women perceiving the task as more difficult than men. There were no significant differences in opinion as to whether target shooting is a male oriented, female oriented or neutral task,  $F(1,38) = .67, NS$ . Noteworthy is that 35.0% of participants viewed target throwing as a male oriented task, 62.5% viewed it as a neutral task while only 2.5% viewed it as a female

oriented task. Bearing in mind the literature reviewed in chapter 2, almost all that was found here was highly predictable. Men outperformed women in target throwing accuracy and overall, considered target throwing as a more masculine than feminine skill. However, an important point is that materials planned to be used with elite level dart players were tested and shown to be effective for the purpose of conducting follow up experiments. Moreover, equally as important is that the International/professional dart players will be tested in the same setting as the university students. There is no doubt there will be highly significant differences in accuracy data between the two populations of university students and professional dart players, but this is not the prime interest. What is of interest is the magnitude and comparability of differences in accuracy between men and women of the two populations and their responses to the questions asked.

#### **4.2.3. Method Experiment 1a.**

##### *Design*

The independent variables in Experiment 1a were gender, with two levels and level of skill with two levels (International/professional and intermediate/county) . The dependent variable was throwing accuracy measured in millimetres (mm), with the lower scores being more accurate than higher scores. The experimental hypothesis was that International/professional level men would be significantly more accurate than intermediate/county level men who would be significantly more accurate than International/professional level women who in turn would be significantly more accurate than intermediate/county level women.

### *Participants*

Participants were 48 elite dart players assembled to participate in the England open darts championship. Subjects were categorised into 4 groups by level of skill and gender. International/professional level men ( $n = 12$ ), International/professional level women ( $n = 12$ ), intermediate/county level men ( $n = 12$ ) and intermediate/county level women ( $n = 12$ ). All participants threw darts with their right hand. For men ages ranged from 16 to 56 years with a mean age of 41.75 yrs ( $SD = 6.27$ ) years for International/professional level men and 41.08 ( $SD = 6.95$ ) yrs for intermediate/county level men. For women ages also ranged from 16 to 56 years with a mean age of 33.92 yrs ( $SD = 8.11$ ) for International/professional level women and 37.33 yrs ( $SD = 12.21$ ) for intermediate/county level women.

### *Materials/Apparatus*

*Questionnaire.* Each participant was asked to respond to questions on a 10 item questionnaire which was completed by an assistant to the author (see appendix 2 for a copy of the questionnaire). The questionnaire provided demographic information such as age, level of skill and gender as well responses to task-related opinions such as ‘How difficult do you think the task of target shooting will be?’ and ‘Do you consider target shooting male oriented, female oriented or neutral?’ The responses to the questionnaire were recorded by both choice alternatives and on a 1 to 7 Likert type scale, where 1 = very difficult and 7 = very easy. The apparatus used was a standard match-play dartboard with a plain surface having only the bullseye depicted as the target area (see appendix 5 for diagram of apparatus). For the purpose of recording the accuracy of each dart a circular piece of light card 194mm in diameter, matched in colour with the surface area of the dartboard, was secured over the centre of the dartboard. A hole was cut out of the card at

the centre, which was placed over the bullseye (target area) on the face of the board. Due to this, any dart that reached its target would not mark the card and would be recorded as a 'hit'. Each player used their own darts which complied with the standards enforced by the governing body of darts under sections 1.1 and 15.09 of their rules and regulations (British Darts Organisation Year Book, 2002).

### *Procedure*

Participants were tested in one session prior to participating in the England open darts championship. Each participant was taken to an isolated area where a dartboard was available for the purpose of conducting the throwing tasks. Prior to conducting the throwing tasks each participant was asked to respond to questions on the questionnaire which was completed by a research assistant. On completion, participants were instructed to throw 12 darts at the target. The landing point of each of the 12 darts was recorded by one of three methods according to accuracy; 1) piercing the card surrounding the target, 2) hitting the bullseye or 3) missing the card completely. Accuracy was recorded by measuring the distance of each point of contact, with the card, away from the perimeter of the bullseye in millimetres. Each bullseye was recorded as zero and each complete miss was recorded as 90 mm (the distance from the perimeter of the card to the edge of the bullseye). The cumulative total for each of the 12 darts thrown was recorded as the total for each player, i.e., the more accurate the player the lower the cumulative score. On completion of the throwing task participants were asked to rate how difficult it was.

**4.2.4. Results and Discussion: Experiment 1a.**

Mean accuracy scores recorded in millimetres (mm) were calculated for both men and women participants for each experimental condition and are reported in Table 4.2.4.1.

**Table 4.2.4.1 Mean accuracy score (measured in millimetres) and corresponding standard deviations for men and women across two levels of skill using their preferred throwing hand (the lower score = higher accuracy).**

Level of Skill						
	International/professional			Intermediate/County		
	Count	Mean	SD	Count	Mean	SD
Men	12	88	50	12	150	38
Women	12	178	65	12	210	86

As can be seen in Table 4.2.4.1 there is a 90mm difference in accuracy in favour of International/professional men over International/professional women, with a low score being more accurate than an high score. There is also a 60mm difference in accuracy in favour of intermediate/county level men over intermediate/county level women. Moreover, the difference in accuracy between intermediate/county level men and International/professional level women is also superior showing a 28 mm difference. Formal analysis of the data was conducted employing a 2 (level of skill) by 2 (gender) factorial ANOVA which found a significant main effect for gender  $F(1,44) = 17.05, p < 0.001$ , a main effect for skill  $F(1,44) = 6.85, p < 0.05$  and no significant interaction. These results support the general trend of previous research by revealing male superiority for dart throwing tasks but are novel inasmuch as these findings are the first to be reported on a unique population of elite dart throwers. By the nature of its design, Experiment 1a was

conducted in the same fashion and, in the main, addressed the same questions as that of Experiment 1a therefore, arguably, Experiment 1a was a mirror image of Experiment 1. Thus, this replication found no fundamental change in the pattern of gender differences between undergraduate and elite performers, merely a change in the magnitude of differences. Formal analysis of the questionnaire data found there were no significant differences in opinion as to whether target shooting is a male oriented, female oriented or neutral task,  $F(1,46) = 1.48$ , NS, which mirrored the findings from undergraduate participants reported in Experiment 1. Moreover, 33.3% of participants viewed target throwing as a male oriented task, 66.7% viewed it as a neutral task while none of the participants viewed it as a female oriented task. There was also a significant difference between genders on their estimates of performance for the opposite gender  $F(1,46) = 24.01$ ,  $p < 0.001$  with men estimating their overall performance as being superior to that of women  $t(23) = 3.92$ ,  $p < 0.01$  and women also estimating their performance as inferior to men  $t(23) = 5.46$ ,  $p < 0.001$ .

### **4.3. Experiment 2: Are there gender differences among elite dart players in their target throwing skills when using their non-preferred hand.**

The aim of Experiment 2 was to investigate the extent, if any, of gender differences in target throwing among an elite group of dart players when using their non-preferred hand. Previous research by Watson and Kimura (1989) using naïve subjects, i.e. college students, found that men significantly outperformed women in two target directed tasks. It was hypothesised that the findings would mirror those reported in Experiment 1a, whereby men would generally outperform women in target throwing accuracy even when using their non-preferred hand.

#### **4.3.1 Method**

##### *Design*

The independent variables in Experiment 2 were gender, with two levels (men and women) and level of skill with two levels (International/professional and intermediate/county). The dependent variable was throwing accuracy measured in millimetres (mm), with the lower scores being more accurate than higher scores. The experimental hypothesis was that International/professional level men would be significantly more accurate than intermediate/county level men who would be significantly more accurate than International/professional level women who in turn would be significantly more accurate than intermediate/county level women.

##### *Participants*

Participants were the same elite dart players as in Experiment 1a being categorised into 4 groups by level of skill and gender. International/professional level men  $N = 12$ , International/professional level women  $N = 12$ , intermediate/county level men  $N = 12$  and

intermediate/county level women  $N = 12$ . All participants threw darts with their non-preferred (left) hand. For the men ages ranged from 16 to 56 years with a mean age of 41.75 yrs ( $SD = 10.15$ ) for International/professional level men and 41.08 yrs ( $SD = 9.96$ ) for intermediate/county level men. For the women ages also ranged from 16 to 56 years with a mean age of 33.92 yrs ( $SD = 8.11$ ) for International/professional level women and 37.33 yrs ( $SD = 12.21$ ) for intermediate/county level women.

### *Materials/Apparatus*

Questionnaire data was not collected during this experiment therefore participants were required to throw darts only. The apparatus used was the same as in Experiments 1 and 1a. Each player used their own darts which complied with the standards enforced by the governing body of darts under sections 1.1 and 15.09 of their rules and regulations (British Darts Organisation Year Book, 2002).

### *Procedure*

Participants were tested in one session prior to participating in the England open darts championship. Each participant was taken, by a research assistant, to an isolated area where a dartboard was available for the purpose of conducting the throwing tasks. Participants were instructed to throw 12 darts at the target. The landing point of each of the 12 darts was recorded by one of three methods according to accuracy; 1) piercing the card surrounding the target, 2) hitting the bullseye or 3) missing the card completely. Accuracy was recorded by measuring the distance of each point of contact, with the card, away from the perimeter of the bullseye in millimetres. Each bullseye was recorded as zero and each



complete miss was recorded as 90mm (the distance from the perimeter of the card to the edge of the bullseye). The cumulative total for each of the 12 darts thrown was recorded as the total for each player, i.e., the more accurate the player the lower the cumulative score.

### 4.3.2. Results and Discussion: Experiment 2.

Mean accuracy scores recorded in millimetres (mm) were calculated for both men and women participants for each experimental condition and are reported in Table 4.3.2.1.

**Table 4.3.2.1 Mean accuracy score (measured in millimetres) and corresponding standard deviations for men and women across two levels of skill using their non-preferred throwing hand (the lower score = higher accuracy).**

Level of Skill						
	International/professional			Intermediate/County		
	Count	Mean	SD	Count	Mean	SD
Men	12	676	81	12	649	84
Women	12	703	118	12	711	108

As can be seen in Table 4.3.2.1 there is a 27mm difference in accuracy in favour of International/professional men over International/professional women, with a low score being more accurate than a high score. There is also a 62mm difference in accuracy in favour of intermediate/county level men over intermediate/county level women. Moreover, the difference in accuracy between intermediate/county level men and International/professional level women is also superior showing a 54 mm difference. Formal analysis of the data was conducted employing a 2 (level of skill) by 2 (gender)

factorial ANOVA which found no significant main effect for gender  $F(1,44) = 2.36$ , NS, no significant main effect for skill  $F(1,44) = .097$ , NS and no significant interaction  $F(1,44) = .37$ , NS.

These results are somewhat in conflict with findings of previous research such as that of Watson and Kimura (1989) who, in their study of hand preference, found striking sex differences in two target directed tasks involving dart throwing and projectile interception. Males were significantly more accurate than females with either hand in both tasks, moreover, this difference did not appear to be attributable to differences in physique or athletic experience. The authors suggested these differences could possibly be related to the 'known male superiority for spatial processing' (Watson and Kimura, 1991, p.375). Furthermore, Bryden and Allard (1998) examined the hypothesis that temporal differences between the hands are often attributed to greater preferred hand practice in everyday tasks. Therefore the effects of extended practice on manual asymmetries was investigated using a pegboard task. Five trials for each hand were performed on the Annett pegboard by a consistent right hander, every day over a period of thirty days. Analysis revealed that overall, extended practice benefited both hands, with the preferred hand improving at a significantly faster rate than the non-preferred hand. The difference between hands, therefore, increased significantly over time. The findings in the current experiment showed no significant gender differences, or differences in level of skill, for dart throwing using the non-preferred hand. Hence, this could provide evidence in support of practice playing a crucial role in determining the level of skill acquired and explaining gender differences found when elite dart players used their preferred hand.

One further noteworthy issue in view of the current results is the concept of 'noise' first reported by Shannon and Weaver (1949). This concept arose from the work of engineers and information theorists who, when working with communication systems, recorded a great amount of spontaneous variability which they termed as 'noise'. This concept has since been used with reference to human behaviour. The amount of noise in a system can be specified statistically, furthermore it has been suggested that additional information is embedded within the noise (Fitts and Posner, 1967). The performance of participants in the current experiment could, arguably, have been subjected to noise when requested to throw with their non-preferred hand, nevertheless it was not within the scope of this thesis to investigate this issue further.

Overall these results do not support the general trend of previous research as gender differences and differences across levels of skill in dart throwing tasks were eliminated when using the non-preferred hand. Results are also novel inasmuch as these findings are the first to be reported on a unique population of elite dart throwers.

#### **4.4. Chapter summary.**

It was established that, what one had come to expect from the performance of undergraduate university students is, in fact, in keeping with the performance of elite men and women dart players when conducting the same experiments. Namely, men outperform women on all aspects of accuracy and levels of skill. Of further interest was the pattern of attitudes toward target throwing with results of the questionnaire data revealing similar responses between undergraduates and elite dart players. Undergraduate men thought they would perform more accurately than their female counterparts as did elite men and women dart players. Furthermore, regarding attitudes toward gender orientation of target throwing,

no significant differences were found between the participants in experiments 1 or 1a. Although over 30% of participants in each experiment viewed target throwing as male oriented, 60% viewed it as neutral whilst only 2.5% viewed it as a female oriented task (all 2.5% came from data collected from undergraduate students). These findings demonstrate that, even following years of extensive training, the pattern of differences in target throwing performance between genders has not changed, with men significantly outperforming women. Moreover, attitudes in relation to target throwing appear to be unchanged by experience. Undergraduate men were found to be more confident in performing the task and perceived the task as less difficult than did undergraduate women, whilst elite men dart players estimated their overall performance as being superior to that of women, a prediction with which elite women agreed. So, interestingly, although a high percentage of elite men actually rated the sport of darts as a non-gendered task they predicted they would do better than their women counterparts. However, the subject of Chapter 5 is to investigate whether the same group of elite participants would reveal such salient gender differences and differences across levels of skill when using their single dart averages as the dependent measure.

## **Chapter 5: Dart averages as a measure of dart playing performance.**

### **5.1. Preface.**

As argued in Chapter 3 single dart averages are a measure of game performance and correlate strongly with the level of skill of dart players. However, it is equally important to examine the relationship between target throwing scores obtained in a non-competitive experimentally controlled situation and single dart averages taken from a competitive 'real world' match environment. It is possible that in a competitive match environment the magnitude of differences between men and women is even greater. This is in consideration of suggestions derived from previous research that suggests women may suffer greater competitive anxiety and exhibit fewer, less effective, anxiety management skills than men (Meyers et al., 1999). If this is the case one would expect that whilst a relatively strong relationship may exist between single dart averages and laboratory based throwing tasks (strengthening the argument that target throwing is the major component of dart playing performance), the strength of relationship would be stronger for men than women. This supporting the notion that women may perform better in a laboratory based setting, with very little, if any distraction, than in the National or International arena whereby they are open to public scrutiny. Thus, the first analysis is to investigate if there is a relationship between laboratory based throwing tasks and single dart averages. If a strong correlation holds it may imply that a major component of dart playing performance rests purely on ones' target throwing ability. This also gives greater credit to using single dart averages not only as a measure of game performance but also as an indicator of target throwing skill. Moreover, with acknowledged difficulties when involving world class participants in laboratory type experiments, one may make reference to unlimited access to single dart

averages when examining factors responsible for game performance and target throwing. Thus, the first aim of Chapter 5 was to examine the relationship between single dart averages and target throwing between genders and across levels of skill. This will be achieved by correlating the target throwing scores of elite dart players examined in Experiment 1a reported in Chapter 4 with their single dart average, obtained during a competitive match situation, the results of which are reported in Study 1.

The second aim of this Chapter was, using the single dart average as the dependent measure, to investigate the extent to which gender differences in dart playing performance exist across three distinct stages of performance namely, International/professional, intermediate/county and superleague/local. This will be achieved by examining the dart playing performance of both men and women dart players under 'real' competitive conditions, across three levels of skill, using the single dart average as the dependent measure, the results of which are reported in Study 2.

The third aim of this Chapter was to investigate whether there is a relationship between physical and experiential factors namely height, arm length, age and length of playing career and dart playing performance. This will be achieved by examining the physical and experiential attributes of a cohort of intermediate/county level dart players using the single dart average as the dependent measure the results of which are reported in Study 3.

## **5.2. Study 1: the relationship between target throwing ability and dart playing performance.**

The aim of study one is to examine the relationship between single dart averages, taken from a 'real world' environment, and target throwing scores obtained under controlled laboratory conditions. This correlation should provide evidence as to the extent of the relationship between single dart averages, target throwing ability, level of skill and relationship by gender.

### **5.2.2. Method**

#### *Sample*

Data from the same 48 elite dart players that took part in Experiment 1a and 2 were employed.

#### *Analyses of Data*

The target throwing data was the same as that collected and analysed for Experiment 1a. The single dart averages for the International players were extracted from official data recorded by officials of the British Darts Organisation. The performance of International level players was calculated by averaging their scores during the Three Nations International series played over a weekend. The single dart averages for the county level players was extracted from official data recorded by officials of the British Darts Organisation during a county match played on the subsequent weekend. Data of both sets of participants was recorded during the 1999/2000 darts season.

### **5.2.3. Results and Discussion.**

Mean accuracy scores for target throwing accuracy recorded in millimetres (mm) and mean single dart averages, along with corresponding standard deviations, were calculated for both men and women participants for each condition of the study and are reported in Table 5.2.3.1. As can be seen for target throwing scores there is a 90mm difference in accuracy in favour of International/professional men over International/professional women, with a low score being more accurate than an high score. There is also a 60mm difference in accuracy in favour of intermediate/county level men over intermediate/county level women. Moreover, the difference in accuracy between intermediate/county level men and International/professional level women is also superior showing a 28 mm difference. For the single dart averages there is a 10.65 point difference in single dart average in favour of International/professional men over International/professional women, with a high average being indicative of superior performance. There is also a 7.12 point difference in single dart average in favour of intermediate/county level men over intermediate/county level women. Moreover, the difference in single dart average between intermediate/county level men and International/professional level women is also superior showing a 6.04 difference. The smallest difference in single dart average is 1.08 reported in favour of International/professional women over intermediate/county level women.



**Table 5.2.3.1. Mean accuracy score (measured in millimetres), single dart averages and corresponding standard deviations in brackets, of men and women across two levels of skill.**

	Level of Skill					
	International/professional			Intermediate/County		
	Count	Mean target throwing	Mean single dart average	Count	Mean target throwing	Mean single dart average
Men	12	88 (50)	32.66 (1.62)	12	150 (38)	28.05 (.65)
Women	12	178 (65)	22.01 (1.73)	12	210 (86)	20.93 (.94)

Formal analysis of the data was conducted employing Pearson's Product Moment Correlation Coefficient which found a significant relationship between target throwing scores and single dart averages for International/professional level men  $r = -.71$ ,  $p < 0.05$  and intermediate/county level men  $r = -.61$ ,  $p < 0.05$ . Analysis of the women's data using the same technique revealed a correlation of  $r = -.51$  for International/professional level players and  $r = -.55$  for intermediate/county level players. Neither of the latter correlations reached significance.

The above finding indicates that a strong component of game performance is indeed related to target throwing skills. Also interesting to note is there seems to be a stronger relationship between target throwing scores and single dart averages for men than for women players. This could be an indication that factors other than target throwing skills have a greater influence on women's performance when compared to their male counterparts. A noteworthy point here is that, in contrast to the experimental setting used to

obtain the dependent measure for target throwing ability reported in experiments 1a and 2. the single dart average is qualitatively different in two important ways. First, it is used as a measure of dart playing performance, as opposed to purely target throwing performance, thus incorporates all facets of dart performance; namely, the target throwing ability for scoring during the initial part of the leg, and the target throwing required to finish a leg (see Chapter 3 for an explanation of strategies/finishing in dart playing). Secondly, the single dart average is obtained under a naturalistic 'real world' dart playing environment, therefore, a number of factors, such as "audience" effects (Graydon and Murphy, 1995) and/or competitive state anxiety (e.g. Martens, Vealey and Burton, 1990) could exert their affect on performance outcomes. The issue of single dart averages and the significant and reliable gender differences obtained in Experiment 1a thus begs the question as to whether such differences are evident across a wider spectrum of skill levels. For example: would gender differences be more marked at the most accomplished 'World level' of dart playing performance as opposed to lower 'local' conditions of game performance where there is less at stake and therefore, arguably, less "external" effect? Or is it the case that men have significantly higher single dart averages than women regardless of the "nature" of the competitive arena? With this in mind the aim of study 2 was to examine dart playing performance across three levels of skill, each representing a qualitatively different performance arena.

### **5.3 Study 2: Extent of gender differences across three levels of skill.**

The aim of this study is to investigate if gender differences in dart playing performance exist across three distinct levels of game performance i.e., International/professional, intermediate/county and superleague/local. This will be achieved by examining the dart playing performance of both men and women dart players under 'real' competitive conditions, representative of each differing competitive arena, using the single dart average as the dependent measure.

#### **5.3.1 Method**

##### *Sample*

The data from 12 male and 12 female dart players across three different levels of dart playing skill namely, International/professional, intermediate/county and superleague/local, were used in this study. The International/professional and intermediate/county level players were the same participants as in study 1 (and experiments 1a and 2). The superleague/local players were selected, based on the top 12 single dart averages for each gender, from teams registered in the London superleague.

##### *Procedure*

The single dart averages for the International players was extracted from official data recorded by officials of the British Darts Organisation. The performance of International/professional level players was calculated by averaging their scores during the Three Nations International Championship (England, Wales and Scotland) series played over a weekend. The single dart averages for the intermediate/county level players was extracted from official data recorded by officials of the British Darts Organisation during a

county match played on the subsequent weekend. Finally, the single dart averages of superleague players was extracted from official data recorded by officials of the British darts Organisation from a superleague match around the same period of time. Data of all sets of participants was recorded during the 1999/2000 darts season.

### 5.3.2 Results and Discussion

Mean single dart averages and corresponding standard deviations were calculated for both men and women participants for each experimental condition and are reported in Table 5.3.2.1. As can be seen in the table, there is a 10.65 point difference in single dart averages in favour of International/professional men over International/professional women, a 7.12 point difference in single dart averages in favour of intermediate/county level men over intermediate/county level women and an 8.98 difference in single dart averages between superleague/local level men and superleague/local level women. Moreover, there is a 4.23 point difference in favour of superleague/local level men (lowest level) and International/professional level women (highest level).

**Table 5.3.2.1. Mean single dart averages, with corresponding standard deviations in brackets, of men and women dart players across three levels of skill.**

	Level of Skill					
	International/ Professional		Intermediate/ County		Superleague/local	
	Count	Single dart average	Count	Single dart average	Count	Single dart average
Men	12	32.66 (1.61)	12	28.05 (.75)	12	26.24 (.77)
Women	12	22.01 (1.70)	12	20.93 (.95)	12	17.26 (.73)

An ANOVA, with gender and level of skill as the two main factors, revealed a significant interaction between gender and level of skill  $F(2,66) = 13.81, p < 0.001$  (see appendix 8 for graphic display of interaction). Plus a main effect for level of skill  $F(2,66) = 138.49, p < 0.001$  and gender  $F(1,66) = 1057.79, p < 0.001$ . As expected players at the superior level of skill performed at a reliably superior level for both men and women as evidenced by separate analyses for men,  $F(2,33) = 104.28, p < 0.001$  and for women,  $F(2,33) = 51.59, p < 0.001$ . Post-hoc comparisons of the group means of level of skill within each gender showed that higher levels of skill were associated with reliably higher levels of dart performance. For example International/professional level men were superior to intermediate/county level men,  $t(22) = 8.95, p < 0.001$  and intermediate/county level men were superior to superleague/local level men,  $t(22) = 5.83, p < 0.001$ . This trend was not mirrored for the women's data where intermediate/county level women were superior to superleague/local level women,  $t(22) = 10.63, p < 0.001$  but International/professional level women were not reliably superior to intermediate/county level women,  $t(22) = 1.92, NS$  when subjected to Bonferroni correction.

An analysis of simple effects for gender found large differences in favour of men, when compared to women at all three levels of skill as shown in table 5.3.2.2.

**Table 5.3.2.2. Simple effects of men and women dart players across three levels of skill.**

International/professional men versus International/professional women	t (22) = 15.70, p < 0.001
International/professional men versus Intermediate/county women	t (22) = 21.66, p < 0.001
International/professional men versus Superleague/local women	t (22) = 30.05, p < 0.001
Intermediate/county men versus International/professional women	t (22) = 11.25, p < 0.001
Intermediate/county men versus Intermediate/county women	t (22) = 20.42, p < 0.001
Intermediate/county men versus Superleague/local women	t (22) = 35.77, p < 0.001
Superleague/local men versus International/professional women	t (22) = 7.82, p < 0.001
Superleague/local men versus Intermediate/county women	t (22) = 14.99, p < 0.001
Superleague/local men versus Superleague/local women	t (22) = 29.17, p < 0.001

Post hoc comparisons for both level of skill and gender were subjected to Bonferroni correction.

The ranges of dart performance for both genders as a function of level of skill (International/professional, intermediate/county and superleague/local) reported in table 5.3.2.1 shows that the performance of all male players exceeds the performance of the best female dart player. A post-hoc analysis confirmed that all three groups of male dart players had a reliably higher level of performance than any of the three female groups, as reported in table 5.3.2.2. In fact, the least accomplished male players at superleague/local level were reliably superior to the female dart players at International/professional level. In view of

these finding one may argue that women's performance shows a less predictable pattern when related to the playing arena, whereas mens' performance reliably improves as the playing arena becomes 'bigger'.

#### **5.4. Study 3: Do physical attributes affect dart playing performance.**

The third aim of this Chapter was to investigate the possible affect that physical and experiential factors such as height, arm length, age and length of playing period may have on dart playing performance. This was achieved by examining the physical and experiential attributes of a cohort of intermediate/county dart players ( $n = 80$ ) using the single dart average as the dependent measure. The results of Study 2 have provided evidence to suggest that the dart playing performance of men is significantly superior to that of women across all three levels of skill investigated, but it is also noticeable that men are, on average, taller than their female counterparts and have, on average, longer arm length. Whether such physical factors alone, are influential in dart playing performance is the subject of the investigation reported in Study 3.

A review of the previous literature indicated that the work of Watson and Kimura (1989) and Watson and Kimura (1991), was the most relevant in relation to the aim of the current study. They found that significant gender differences in favour of men on two target-directed tasks, i.e., intercepting and throwing; were not reducible to differences in physique or athleticism.

##### **5.4.1. Method**

###### *Sample*

Players ( $n = 80$ ) were selected from a population of County A team players ( $n = 360$ ) representing teams from England and Wales currently participating in the Premier Division of British Inter-County Darts Championship (regional level of performance). In order for data from players to be included in the current study they must have participated



in at least 8 matches during the current season (9 being the maximum possible) including the last match. Once these criteria had been met the top 40 male and 40 female dart players, based on their single dart average, were selected.

### *Procedure*

Each participant was interviewed to obtain information about their age and length of dart playing career at this competitive level (measured in months). Furthermore, the participants' height and arm length in inches were measured and recorded. Arm length was measured from the top of the throwing arm at the shoulder bone to the tip of the middle finger. The participants' dart performance, i.e., single dart average, was obtained from archival data based on the official records for 1997/98 British Inter-County Dart Championships kept by the British Darts Organisation. Data were extracted from each players' individual match scores played during the final match in the Premier division of the 1997/98 season.

### **5.4.2. Results and Discussion.**

The height (in inches), arm length (in inches), previous experience (in months), age (in years) and single dart averages of the two samples of men and women intermediate/county dart players are reported in table 5.4.2.1. There is approximately a 5 inch height advantage for men over women and approximately a 2 inch advantage for men in arm length. Both groups had played darts for a comparable period, on average over ten years, and on average women were approximately 4.5 years older than men. The difference in single dart averages between the groups was over 8 points in favour of men.

**Table 5.4.2.1. Mean height (in inches), arm length (in inches), previous experience (in months), age (in years) and single dart average, all with corresponding standard deviations in brackets, of men and women county level players.**

	Intermediate/County level dart players					
Gender	Count	Height	Arm length	Previous experience	Age	Single dart average
Men	40	71.0 (2.7)	30.8 (2.3)	139.1 (59.7)	34.6 (6.7)	28.8 (2.3)
Women	40	66.1 (2.7)	28.5 (2.2)	131.3 (65.3)	39.2 (9.1)	20.2 (3.5)

As expected, the heights,  $t(78) = 8.27, p < 0.01$  and arm lengths,  $t(78) = 4.70, p < 0.01$  were greater for men than women and the dart performance of men was superior to that of women,  $t(78) = 13.11, p < 0.01$ . To assess whether differences in height and arm length could explain the difference in dart performance a regression analysis was conducted. Participants' height and arm length reliably predicted their dart performance (increase in R-square = .397). However, these two variables did not explain all the variation associated with gender because adding gender to the regression equation led to reliable improvement in prediction (increase in R-square = 0.297). Most importantly, height and arm length did not contribute any systematic information independent of gender because when these variables were removed from the regression equation the reduction in R-square was not reliable. The findings from the regression analysis show that the relation between height and arm length on the one hand, and dart performance on the other, is fully explained by normal gender differences in these variables rather than direct influences on performance. In further support of that conclusion no reliable correlations were found between height, arm length, previous experience, age and dart performance when the data for men or women were analysed separately.

These overall findings support previous research reported by Watson and Kimura (1989) and Watson and Kimura (1991) whereby significant gender differences in favour of men were found on two target-directed tasks, i.e., intercepting and throwing; they concluded these differences were not reducible to differences in physique or athleticism.

### **5.5. Chapter summary.**

The present Chapter fulfilled the aim of finding a strong relationship between target throwing and single dart averages, a parallel and significant gender difference on single dart averages across all levels of competitive performance and, finally, the fact that such difference are not attributable to physical or experiential variables.

The findings revealed that men show a strong and reliable relationship between laboratory based target throwing and actual game performance, but this was not the case for women. In all types of playing arena and across levels of skill one could reliably predict target throwing accuracy and game performance for men, whilst for women the pattern is somewhat disturbed. Moreover, there is no indication that purely physical or experiential attributes are responsible for such predictable differences in performance. These results, together with findings that men and women show no difference in performance when using their non-preferred hand lead one to explore yet another important issue in sporting achievement, namely, the role of deliberate practice and related factors (Ericsson, et al., 1993). Thus far, this has been reported continuously in the literature review as, arguably, playing a crucial role in the acquisition of expert performance and will therefore be the topic covered next in Chapter 6.

## **Chapter 6: The Theory of Deliberate Practice and the Acquisition of Expertise.**

### **6.1 Preface.**

The aim of this thesis was twofold; first, to examine the extent of gender differences amongst dart players of differing levels of skill in target throwing and dart playing ability; Secondly, to investigate possible factors that contribute to the acquisition of expertise in target shooting and dart playing ability. So far, by the implementation of both experimental and quasi-experimental methods, several of the initial questions raised have been addressed; namely, there is indeed a significant gender difference in target throwing ability with results showing superiority for men for both a naïve and elite population (Experiments 1 and 1a). Moreover, there is a significant relationship between target throwing ability and dart playing performance as noted by a correlation between the two measures (Study 1) and significant gender differences in dart playing performance are observable across different levels of skill (Study 2). This is in view of significant differences found between dart averages of men and women at International/professional, intermediate/county and local/superleague level. In Study 3 height and arm length were eliminated as possible contributing factors to the level of skill one may acquire in this sport.

A follow-up aim of this thesis is to examine a number of key factors identified in previously reported research by Ericsson et al., (1993), particularly the role of deliberate practice in the acquisition of throwing skill amongst male and female dart players. Indeed, the observation of a null effect for gender differences in target throwing (Experiment 2) when using the non preferred hand could be taken as an indication that perhaps practice

plays a significant role in the development of target throwing and dart playing expertise. If so, one would expect that amongst the key determining factors (as listed below) argued to play a role in the development of expertise, deliberate practice is a significant contributing factor.

With this in mind, the focus of this thesis now turns to investigating which of the following factors namely, deliberate practice, playing for fun, playing league, playing competitions and practising with a partner, could account for differences between men and women and different levels of expertise. To examine these factors the framework used by Ericsson, et al., (1993), when formulating their theory of deliberate practice, will be adopted. Particularly, these aims will be achieved via ex-post facto research using semi-structured interview based data collection and analyses, similar to that used by Ericsson et al., (1993). The first part of Chapter 6 therefore provides a definition of the Theory of Deliberate Practice and highlights how this theory is somewhat in contrast to an 'innate ability' or talent account of the acquisition of expertise. Furthermore, an overview of previous research findings will be reported in addition to providing evidence in support of the methodology implemented. Finally, the research reported in study 4 of this thesis aimed to investigate the role of practice, and other related variables (as listed above), and specifically, how they may contribute to gender differences and differences in level of skill.

## **6.2 Introducing the Theory of Deliberate Practice.**

The Theory of Deliberate Practice, first proposed by Ericsson, et al., (1993), is one paradigm that could, arguably, explain not only differences in level of skill but differences between genders also. According to their model, which was based on interview data from two studies with pianists and violinists of varying levels of skill. They propose that expertise can be explained by an information-processing (or skills) approach, whereby expert performance is the end result of an individual's prolonged efforts to improve performance through knowledge, and skills acquired through practice, while also negotiating motivational and external constraints. They suggest that years of active learning (practice), intended solely for the purpose of improving one's skill in a specific domain, is required to attain expert levels of performance. They termed such focused activities as 'deliberate practice'. Investigating the acquisition of expertise within the framework of this theory has recently gained popularity in several divergent domains such as music (see Lehmann, 1997), the work place (see Sonnentag and Kleine, 2000), team sport (see Helsen, et al., 1998) and individual sport (see Hodges and Starkes, 1996). Arguably this popularity has emerged due to two main reasons. First, this theory offers scope for some generality with respect to the acquisition of expertise which can be used as framework to investigate expertise in a wide range of activities. Secondly, it offers an opposing paradigm to those who propose the 'talent' theory of expertise whereby high-achieving individuals acquire their outstanding skill with the same, or even less, practice than others (Gardner, 1983, cited in Ericsson and Charness, 1994).

### **6.2.1. The tenet's of Ericsson et al.'s (1993) theory.**

Based on a review of a century of laboratory studies of learning and skill acquisition Ericsson, et al., (1993) concluded that 'the most effective learning requires a well-defined task with an appropriate difficulty level for the particular individual, informative feedback, and opportunities for repetition and corrections of errors'. When all these elements are present they used the term 'deliberate practice' to characterise training activities. They argue that when these criteria are used to examine many of the areas of expertise investigated in the literature it becomes apparent that most individuals actively participating in a domain spend very little, if any, time engaging in deliberate practice. In fact, the vast majority of time is spent engaged in playful, effortless domain related activities for the primary purpose of enjoyment. Ericsson et al., (1993) distinguish three general types of activities, which are domain related: work, play and deliberate practice. Work includes public performance, competitions, services rendered for pay and other activities directly motivated by external rewards. Play includes activities that have no explicit goal and are inherently enjoyable. Deliberate practice includes activities that have been specially designed to improve the current level of performance. The goals, costs and rewards of these three activities differ, as does the frequency with which individuals pursue them. Indeed when examining the sport of darts and its peculiarities, one may argue that whilst it is difficult to discriminate between different facets of practice in many other sports, one can readily isolate and thus investigate, practice activities in darts. Arguably, for outsiders, playing darts is seen primarily as a social activity engaged in for fun and relaxation usually in a pub/club environment. Indeed, today's elite dart players have, in the most part, emerged typically from that very environment. Thus, a careful examination of the differences between practice as fun in contrast to deliberate practice among elite dart

players could serve to further our knowledge of these supposedly 'exclusive' activities as proposed by Ericsson et al., (1993). For an indepth account of the differences between these activities see Ericsson et al., (1993).

When applied to an individual their theoretical framework makes three types of predictions concerning the developmental history of experts, current levels of performance and evaluations regarding the nature of deliberate practice and its affect on the level of performance one may acquire. They argue that these predictions could be generalised to other domains. First; their predictions regarding developmental history suggests that an individual's past amount of deliberate practice is directly related to their current performance. This they termed the "monotonic benefits assumption". However they do emphasise that one must meet all the conditions of deliberate practice (ie. engage in a well-defined task with an appropriate difficulty level for the particular individual, informative feedback, and opportunities for repetition and corrections of errors) to improve one's level of performance. Therefore, improvement is a function of the *quality* and *amount* of deliberate practice, experience alone in a particular domain is not a reliable predictor of improvement unless you engage in the appropriate activities. Furthermore, expertise is not reached with less than 10 years of deliberate practice in a specific domain, which will start at low levels and increase slowly over time (Ericsson et al., 1993). Secondly, Ericsson et al.'s predictions about current levels and habits of practice claimed that the highest improvement in performance, and indirectly the highest attained performance, is associated with the largest weekly amounts of deliberate practice (Ericsson et al., 1993). Finally, they made predictions about experts' evaluations regarding the nature and role of deliberate practice activities. They predicted that deliberate practice would rate very high on relevance for performance, high on effort and comparatively low on inherent enjoyment.



They argued that deliberate practice is not inherently enjoyable but individuals engage in it as an instrumental means to improve their performance. In support of this claim they cite studies showing that individuals who gave up their goal to improve their performance in a particular domain soon after reduced their amount of deliberate practice to a level comparable with that of a novice in the same domain. They illustrate the differential between the task (deliberate practice) and the outcome (level of performance) using the example of house cleaning. One may not necessarily 'inherently enjoy' the task (cleaning the house) but would enjoy the outcome (having a clean house).

Questions related to the main predictions of Ericsson et al.'s (1993) theory, namely issues concerning the developmental histories of experts, current levels of performance and evaluations regarding the nature of deliberate practice and its affect on the level of performance one may acquire, were incorporated in the interview schedules used in this thesis, the findings of which are reported and discussed in Study 4.

### **6.2.2. Previous research findings.**

Although Ericsson et al.'s (1993) theory is based on studies with musicians, their framework has been used to investigate deliberate practice in several sporting domains, namely Chess (Charness, Krampe and Mayr, 1996), Wrestling (Hodges and Starkes, 1996), Figure Skating (Starkes, et al., 1996), Soccer and Field Hockey, (Helsen, et al., 1998) and Karate (Hodge and Deakin, 1998). Generally, particular predictions integral to the theory have been supported when tested in certain sports. For example; Hodge and Deakin (1998) investigated two groups of Martial Arts students (N=10), the expert group were all Black Belts (mean age 18.4 years) and the novices were either Green or Orange Belts (mean age 17.4 years). The participants were administered questionnaires aimed at investigating their developmental history, weekly amounts of practice (alone and /or with others), activities

other than practice relevant to Martial Arts and activities completely unrelated to karate. A total of 31 activities were investigated.

There were several points of convergence between the work of Hodge and Deakin (1998) and previous research findings. First; the requirement of high concentration for practice, and that practice is highly relevant to the level of performance one may acquire, was strongly supported by Martial Artists, as it was with Musicians (Ericsson, et al., 1993), Figure Skaters (Starkes et al., 1996), Wrestlers (Hodges and Starkes, 1996) and Soccer and Field Hockey players, (Helsen, et al., 1998). Secondly, those practice activities rated as most relevant for improving performance were those which most closely replicated what the athlete or musician is expected to do during an actual performance. For example; in Karate, attending classes and kata training with others were considered two of the most relevant activities by karate students. Similarly, mat work and working with a coach were the two most relevant activities for wrestlers (Hodges and Starkes, 1996). Lessons with a coach and on-ice training received the highest rating for figure skaters (Starkes, et al., 1996); practice alone and lessons were deemed most important for the musicians (Ericsson et al., 1993). Thirdly, much of the above research has also shown that practice is not always perceived as an activity that is low on inherent enjoyment. Moreover, it has shown that participants questioned rated those practice activities which are directly related to actual performance as 'high on enjoyment' Hodges and Starkes, (1996) and Hodges and Deakin, (1998). Arguably, these studies did not capture the essence of what is actually meant by deliberate practice being rated as 'low on inherent enjoyment' and therefore their findings may not necessarily contradict those of Ericsson et al.'s (1993). Researchers (Hodges and Deakin, 1998; Hodges and Starkes, 1996) failed to distinguish between inherent enjoyment in the activity itself (ie. deliberate practice) as opposed to enjoyment in

the outcome (improved performance), therefore the ratings given by participants could be confounded. No clear distinction emerged between physical effort or concentration in Hodge and Deakin's (1998) findings, therefore one cannot assume which, if either, is the more important when defining deliberate practice in the Martial Arts.

The above points, arguably, serve to highlight how significant it will be to investigate the nature of practice in a sport such as darts, where practice activities are closely related to those activities relevant to competitive game performance.

In a recent review by Starkes (2000) aimed, in part, at investigating the role of practice within Ericsson et al.'s (1993) theory in relation to several team and individual sports evidence for the "monotonic benefits assumption" was clear for individual sports such as Figure Skating and Wrestling. Evidence in support of this particular assumption was less evident from team sports, such as Soccer and Field Hockey. Starkes (2000) suggests three reasons for this. First; in team sport, much of the training and practice is determined by a coach. Therefore the absolute amount of accumulated practice may be less predictive for any one individual performance attained. Secondly; it appears that in team sports what actually constitutes 'deliberate practice' is less clear than in individual sports. For example: individuals could engage in two different forms of practice i.e., team practice and individual practice, and the relative contribution of each of these will almost certainly change during the course of one's career. Thirdly; Starkes, et al., (2000) implies that it may be the nature and structure of the two team sports examined (i.e., Soccer and Field Hockey) that determines the lack of strong evidence for the monotonic benefits assumption. Findings could be to the contrary if alternative team sports were investigated. One may argue then from this last point that any sport investigated within the framework of this

theory, whether it be individual or team based, should be considered in isolation if we are to enhance our knowledge to the full.

Hodge and Deakin's (1998) work with Martial Arts students did find support for the monotonic benefits assumption, whereby practice did differentiate between two levels of skill; Karate related practice activities did increase with performance until reaching Black Belt status.

### **6.2.3. The Theory of Deliberate Practice - data collection and analyses.**

A central prediction of Ericsson et al.'s (1993) theory was that " adult elite performance, even among individuals with more than 10 years of practice, is related to the amount of deliberate practice" (p. 373). This prediction is based solely on the self-report retrospective recall of musicians used in the two studies reported in their paper. In brief; the violinists in study 1 were interviewed during three sessions. During the first session biographical information was obtained including when they had started solitary practice and how many hours per week had they practised for each year since the onset of practice. During this session the violinists were also given a taxonomy of 10 *everyday* activities, 12 *music related* activities and a further 8 musical categories not related to the violin. Their task was to estimate, on average, how much time they had spent engaging in each activity during the most recent typical week. Subjects were also asked to rate each activity on three dimensions using a 0 - 10 scale, whereby 0 = low, 5 = average and 10 = high. The three dimensions were how relevant they felt the activity was for improving performance, how much effort was required to perform the activity and how enjoyable the activity was. During the second session subjects answered questions about practice and concentration.

They were also asked to recall activities they had engaged in during the previous day. For this recall they used a specially designed diary sheet which divided the 24 hour day into 96 x 15 minute time slots. After completing the recall of the previous 24 hours subjects were asked to encode all the activities they had engaged in using the 30 categories of the taxonomy. They were then asked to keep 24 hour diary sheets for a full seven day week. During the third and final interview session subjects were invited to discuss any questions they had regarding their encoding and 24 hour diaries. Following this the interviewer asked questions about the subjects' developmental life goals and engaged in general debriefing. In study 2, Ericsson et al., (1993) again gathered data via retrospective reports over two sessions, including subjective estimates of past amount of deliberate practice, this time using expert and amateur pianists. The main prediction for study 2 was that it would be possible to predict differences in proficiency for skill-related tasks at least as well from the measures obtained of accumulated practice as from the differences in the pianists' level of expertise. Clearly then, as stated previously, the main technique underpinning Ericsson et al.'s (1993) theory of deliberate practice is data collection by way of retrospective recall. One of the main criticisms of their theory, outside of the 'deliberate practice' supporters, has focused on the use of retrospective recall as data as credible data.

The majority, if not all, of the studies to date investigating deliberate practice in various domains of expertise have relied heavily on data gathered via retrospective recall methods supplied by the experts themselves and significant others. Historically, much of the knowledge we have acquired regarding 'outstanding' individuals and expertise in general has been subject to possible biases of this type of data collection; i.e., retrospective recall. This problem is based purely on pragmatics; the outstanding achievements of exceptional individuals are usually only recognised as such by society years, decades or even centuries

after the event. Consequently personal accounts from experts are necessarily retrospective by nature (Ericsson and Charness, 1995). One strong argument favouring the accuracy of recall for experts from several different domains is that practice is usually highly structured and has constituted such a large part of their everyday life that specifics regarding the nature and length of practice routines are readily recalled (Starkes, 2000). This, along with accounts substantiated by significant others, i.e., parents, teachers and coaches, adds to the credibility of retrospective reports as data. Moreover, the structure and planning involved in successful practice routines dictates that incorporated activities generally remain the same over periods of months and even years. This reflects the developmental nature of the acquisition of expertise whilst also lends support to the argument that recall of such activities is not as difficult as one may, initially, be led to believe. However, to add strength to using retrospective recall one could verify reports by asking interviewees to check their diaries, accounts and schedules. This was the procedure used for dart players.

#### **6.2.4. Retrospective recall as credible data.**

In order to substantiate data collected via retrospective recall, researchers in the past have required their participants to complete detailed diaries. The diaries usually cover a 7 day period, which is then compared with the subjects subjective reports of accumulated practice and other activities (see Ericsson, et al., (1993); Hodges and Starkes, (1996) and Helsen, et al., (1998) for examples). Although data collected via retrospective recall is not generally a preferred method of data collection it has been used extensively in many areas of scientific enquiry such as; incidents of child abuse ( Maughan and Rutter, 1997; Cohen, Brown and Smailes, 2001; Higgins and McCabe, 2001), addictive behaviours (Ernhart, Morrow-Tlucak, Sokol and Martier, 1988; Dierker, Avenevoli, Merikangas, Flaherty and

Stolar, 2001), functional status of the elderly (Covinsky, Palmer, Counsell, Pine, Walter and Chren, 2000), learning and academic achievement (Gilger, 1992; Dunlosky and Hertzog, 2001;) and physical development ( Gilger, Geary and Eisele, 1991). In fact, in a paper by Brewin, Andrews and Gotlib (1993), the authors state that " evidence reviewed suggests that claims concerning the general unreliability of retrospective reports are exaggerated" (p.82).

As mentioned at the end of section 6.2, one of the most attractive aspects of Ericsson et al.'s (1993) theory is that it offers an opposing paradigm to those who propose the 'talent' theory of expertise, whereby high-achieving individuals acquire their outstanding skill with the same, or even less, practice than others. Arguments for and against the role of "talent" in the acquisition of expertise are discussed in the next section.

### **6.3 Deliberate practice or talent? Evidence as contributing factors for expert performance.**

Ericsson et al., (1993) claim that often, even when individuals have the opportunity to utilise similar training environments, large individual differences in the level of performance attained will emerge. They refuted the notion that these differences in performance are evidence for innate differences in ability (i.e., talent), and that experts are not qualitatively different to non-experts. "If genetic factors rigidly determine maximal performance, it is reasonable to assume that these genetic factors cannot be influenced by practice and training and hence remain stable across time". This quote, taken from Ericsson et al., (1993, p. 364), clearly demonstrates the authors opposition to an hereditary basis for the acquisition of expert performance. They argue that salient differences in physical attributes between athletes of differing levels of skill, and even normal adults, are " often

simply assumed to reflect pure genetic factors". Moreover they argue that "some of these differences may not be innate but instead be the result of physiological adaptations to extremely intense practice extended over many years" (p.394). They do in fact make two concessions to this belief. First in the case of height, whereby they state "height is an excellent example of a characteristic for which the genetic mechanism has clearly been demonstrated" (p. 394) and, secondly, they make the rather ambiguous statement, that "although we claim that genetic factors have little direct impact on ultimate adult performance, a plausible role for hereditary factors is in the development history of an individual. Superior performance by very young children without prior instruction may suggest exceptional promise, leading to the early onset of training". However, this second point in effect supports their argument for the salient effects of accumulated practice as early onset of training leads to a consistently greater accumulation of practice. Ericsson et al., (1993) support the argument that experts start actively participating in their area of expertise during childhood, a notion first implied by Bloom (1985), who interviewed several International level performers from different domains. Ericsson et al., (1993) claim this early onset of activity within a particular domain makes it virtually impossible to separate innate abilities from experience and deliberate practice. Moreover, they claim that "the conviction in the importance of talent appears to be based on the insufficiency of alternative hypotheses to explain the exceptional nature of expert performance" (Ericsson, et al., 1993, p. 365).

Ericsson et al., (1993) claim that most people begin a regimen of effortful activities designed purely to optimise improvement on a particular task (which they describe as deliberate practice) in their childhood. Ericsson et al., (1993) work within what they describe as the 'monotonic benefits assumption', which basically states that the amount of



time an individual is engaged in deliberate practice activities is monotonically related to that individual's acquired performance. Even individual differences within experts can be accounted for within this assumption (namely the amount of deliberate practice). Nevertheless, Ericsson et al., (1993) do suggest that heritable individual differences might influence processes related to motivation and the original enjoyment of the activities within a domain, and, even more importantly, "affect the inevitable differences in the capacity to engage in hard work" (deliberate practice, Ericsson et al., 1993. p. 399). They further point out that it does not follow from the rejection of innate limits on acquired performance that everyone can easily attain high levels of skill. One needs to have "early access to instructors, have maintained high levels of deliberate practice throughout development, received continued parental and environmental support and avoided disease and injury" (p. 400). Ericsson et al., (1993) further claim that, in addition to the above points, "when one considers the prerequisite motivation necessary to engage in deliberate practice every day for years and decades, when most others are engaging in play and leisure, the real constraints on the acquisition of expert performance become apparent" (p. 400). Interestingly, in view of the contents of Study 4 of this thesis, they suggest that more careful analysis of the lives of elite performers will give insight into how motivation is promoted and sustained. Such detailed analysis will reveal the environmental conditions, as well as heritable individual differences, that predispose individuals to engage in extended periods of deliberate practice. Ericsson et al.'s (1993) empirical studies have already shown that experts carefully schedule deliberate practice and limit its duration to avoid exhaustion and burnout. By looking at expert performers as not only domain-specific experts, but experts in maintaining high levels of practice and improving performance, one may be likely to uncover valuable information about the optimal conditions for learning and education. In a later paper Ericsson and Charness (1994) again show no support for

fixed innate characteristics that would correspond to general or specific natural ability. They claim "the role of early instruction and maximal parental support appears to be much more important than innate talent" (p. 729). They further claim to have uncovered evidence to the contrary by stating "there are many examples of parents of exceptional performers who successfully designed optimal environments for their children without any concern about innate talent" (p. 729).

Gardner (1995) challenges Ericsson and Charness (1994) arguing that their account of the acquisition of expert performance, by way of deliberate practice, is "ambitious" (p. 802) as it "challenges the commonly held assumption that certain individuals are endowed with far more with gifts, talents or 'innate capacities' than others" (p. 802). Gardner claims that, "few if any contemporary researchers claim that some individuals are born with innate knowledge of a domain" (p. 802), rather, the question is, whether certain individuals may be more disposed early on to explore a domain and whether as a consequence they may progress significantly more rapidly in that domain. Ericsson and Charness (1994) did concede that some children may show a inclination toward a particular domain but they attributed this to individual differences in interest, motivation, or temperament rather than talent. However, talent could be viewed as an amalgam of these and other traits including those involving cognition, such as strategic ability. A rather extreme example is used by Gardner to demonstrate Ericsson and Charness's (1994) position when he states " they (Ericsson and Charness) would have to maintain that youngsters and domains could be sorted and matched at random. I doubt that they would attempt to defend this position" (p. 802). Gardner suggests the most crucial question is, once a child has begun actively taking part in a domain, will there be quantitative or qualitative differences in the way they approach and ultimately succeed in that domain. Ericsson and Charness (1994) suggest that

all children work in a domain in roughly the same way with the major distinguishing factor being the amount of deliberate practice. Gardner argues against this for two main reasons. First, he states that, to date, the psychological variable most intensively investigated is that of psychometric intelligence or *g* and one can find very little, if any, evidence to suggest that any kind of practice will produce significant differences in performance (see Herrnstein and Murray, 1994). Gardner also maintains that it is somewhat obvious that when an individual combines 'high psychometric intelligence' in childhood with diligent practice in (and out of) school, they are more likely to become expert thinkers or scholars than those who can only practice (so-called overachievers) or those who do not practice at all (so-called underachievers). One would expect a similar outcome on any complex task, as opposed to one that is largely drill.

Gardner further argues that a second reason to refute Ericsson et al.'s (1993) suggestion that all 'youngsters work in domains in roughly the same way, with the major distinguishing variable being the amount of deliberate practice', (Gardner, 1995. P. 802) centres more on *which* children engage in deliberate practice for long periods of time. Gardner claims this variable is affected by several different factors including parental control, societal norms and personal ambition. Gardner argues " it requires a blindness to ordinary experience - as well as to decades of psychological theorising to deny that a major variable operating on most individuals is their own success at a particular pursuit" (p. 802). It does seem reasonable to suggest that if one does not enjoy success at a particular task how likely are they to persevere with that task. Perhaps a more fruitful line of research would be to ask 'who starts and why? Who continues, why and in what ways do those who continue successfully differ from others'?

Finally, a significant point on the practice versus talent issue was raised by Davids (2000) when suggesting that "the search for groups with precocial talents and low levels of accumulated practice may lead to the discovery of some important information on the constraint of innate abilities" (p. 8). Indeed this is a valid point. To uncover groups of experts, or individuals within groups, that demonstrate low levels of accumulated practice when compared to their counterparts, or alternatively individuals who demonstrate high levels of accumulated practice but low levels of performance, will highlight the need to investigate the role of talent in the acquisition of expertise even more closely.

In short, it was argued here that Ericsson's theory of deliberate practice is a significant framework within which to explore the reasons for men dart players significantly outperforming women dart players, irrespective of their level of skill. Moreover, factors contributing to the acquisition of skills, within a particular gender group, could also be explored within Ericsson's (1993) framework. Possible critiques of Ericsson's approach and its contribution to the literature on expertise were discussed. The remainder of Chapter 6 reports an investigation of elite men and women dart players. Data was collected via semi-structured interviews the findings and discussion of which are reported next in Study 4 of this thesis.

#### **6.4. Study 4: An investigation of elite dart players via semi-structured interviews.**

The aim of the semi-structured interviews was twofold; First to investigate the extent to which predictions outlined in Ericsson et al.'s (1993) theory of deliberate practice are applicable to men and women dart players across two levels of skill. Secondly, to investigate if any differences in activities between these groups exist, therefore providing evidence that could further enhance the issue of factors contributing to levels of skill and gender differences among elite dart players.

##### **6.4.1. Semi-structured interview study of elite dart players.**

The semi-structured interview schedule used in this study was a modified version of that used by Ericsson et al., (1993) in their study with musicians. The majority, if not all, of the studies to date investigating deliberate practice in various domains of expertise have relied heavily on data gathered via retrospective recall methods supplied by the experts themselves and significant others. Historically, much of the knowledge we have acquired regarding 'outstanding' individuals and expertise in general has been subject to possible biases of this type of data collection; i.e., retrospective recall. This problem is born purely of pragmatics; the outstanding achievements of exceptional individuals are usually only recognised as such by society years, decades, or even centuries after the event. Consequently personal accounts from experts and significant others are necessarily retrospective by nature (Ericsson and Charness, 1995). One strong argument favouring the accuracy of recall for experts from several different domains is that practice is usually highly structured and has constituted such a large part of their everyday life that specifics regarding the nature and length of practice routines are readily recalled (Starkes, 2000. p.

433). This, along with accounts substantiated by significant others, i.e., parents, teachers and coaches, adds to the credibility of retrospective reports as data. Moreover, the structure and planning involved in successful practice routines dictates that incorporated activities generally remain the same over periods of months and even years. This reflects the developmental nature of the acquisition of expertise, whilst also lending support to the argument that recall of such activities is not as difficult as one may, initially, be led to believe. Specifically, in the sport of darts, when International/professional dart players practice alone, or with a practice partner, this is an habitually organised activity. Therefore its duration can be readily estimated. Moreover, as dart playing is their profession, activities such as playing in competitions, exhibition matches and league darts are scrupulously recorded for financial purposes. These records were used to support estimates provided by the International/professional level dart players for the purpose of the schedule.

In the case of intermediate/county level players practice activities are noticeably more haphazard than those of their professional counterparts, particularly in being far less frequent and/or structured. This is reflected in the data collected via the interview schedule. As a consequence estimates of its duration are less readily obtained. In contrast, for the intermediate/county level players, playing in competitions and league matches are highly structured and data pertaining to these activities are readily estimated.

In essence, the interview schedule was designed to elicit biographical information from all four groups of players regarding the following information: dart playing developmental history, structure and quantity of practice and current level of performance. Furthermore, the schedule measured players' evaluations regarding the nature of deliberate practice and its affect on the level of performance one may acquire. Questions were asked during the interview such as; how old were you when you started playing darts regularly? How long do you practice in a typical practice session? Do you practice on specific shots or segments of the board? A further section required participants to rate 4 dimensions of practice on a scale of 0 -to 10 where 0 was low 5 was average and 10 was high. The 4 dimensions were i) How relevant is practice to the level of performance one may acquire? ii) How much physical effort is required when practising? iii) How much concentration is required when practising? iv) How enjoyable are practice sessions?

A further section of the interview schedule included an activity chart designed to record the number of hours each participant spent engaging in various types of performance related activities. Each completed chart recorded specific information regarding the accumulated number of hours spent playing in competitions, league matches, exhibition matches (International/professional level only), practice with a partner, solitary 'deliberate practice' and playing for fun with friends throughout each players career. Further space provided on the chart allowed interviewees to report any other activity that, they felt, contributed to their level of performance such as, participation in other sports, mental imagery and/or hypnosis plus reading about and/or observing others' playing darts.

In brief the following main points were investigated;

- An examination of the participants' ratings on four separate dimensions of practice, namely; how they rate practice on relevance for improving dart playing performance, how much physical effort practice required, how much concentration practice required and how enjoyable practice was. The ratings were reported using a scale of 0 - 10, where 0 was low, 5 was average and 10 was high. Should there be significant differences on these variables between groups then it could be argued that attitudes towards practice could have a significant effect on performance.
- Variables relating to dart playing activities were investigated, namely; playing in competitions, playing for fun, playing league and engaging in deliberate practice. Should there be significant differences across levels of skill and between men and women, in the amount of time engaged in these activities, then they could be argued to have an affect on performance.
- Finally, the Ten Year Rule and playing in exhibition matches will be investigated for International/professional level players only. Although these variables may not contribute to the acquisition of expertise an investigation of the Ten Year Rule should provide evidence as to how long dart players take to acquire International status. Thus, a comparison can be made with elite performers in other sports. Additionally, an investigation of the frequency and players' evaluations of playing in exhibition matches could provide evidence as to the effect of this activity in improving dart playing performance.



#### **6.4.2. Sample.**

The sample targeted in this study were 12 International/professional male dart players, mean age 41.75 years, S.D = 6.27, 12 intermediate/county level male dart players, mean age 41.08 years, SD = 6.95, 6 International/professional female dart players, mean age 36.67 years, SD = 6.15 and 6 intermediate/county level dart players, mean age 42.00 years, SD = 5.51. All participants were right-handed throwers. The criteria for both male and female International/professional level players was as follows; i) to have attained International level of performance, ii) to have professional status recognised by the sports governing body, iii) at least one singles win at World level and five singles wins at International Open Championship level, and iv) to be ranked in the top 16 of the World rankings for at least 75% of their playing career. The criteria for both male and female intermediate/county was as follows; i) no attainment of International level of performance, ii) to have amateur status as recognised by the sports governing body and iii) to have played county darts for a duration of at least 10 years. Due to the strict nature of selection criteria for the group of International/professional level players it was difficult, if not impossible, to select more than 6 women dart players. This determined that 6 women county/regional level players were selected to provide the appropriate match.

#### **6.4.3. Procedure.**

The data collection procedure for all four groups of dart players was identical and covered a span of three years from 1998 to 2001. All data was collected during personal interviews with the participants and included information up to the end of the 1998 dart playing

season, hence ensuring the same finishing point for all participants. Appointments were made with each participant and information regarding the nature and purpose of the impending interview was given to the participant by the author. This enabled each participant to gather relevant information regarding their dart playing careers and gave them a timeframe whereby they could best recall the timing and nature of activities in which they had engaged during this period. The framework of the interview was similar to that employed by Ericsson et al., (1993) in their interviews with musicians. The schedule used for each participant in each of the four groups was identical and incorporated 88 questions in 7 sections plus an Activity Chart. The 7 sections of the schedule included 1) general biographical, 2) darts biography, 3) specific practice, 4) general practice, 5) the role of practice in maintaining level of performance, 6) performance career and 7) memory and performance problems (see appendix 6 for complete semi-structured interview schedule). The activity chart was designed to enable each participant to record the weekly number of hours spent in engaging in those activities most relevant to dart playing performance (see appendix 7 for activity chart).

Data were also collected in order to investigate the “Ten Year Rule” (see section 3.3.2.1. for details). In brief, previous researchers have found evidence to suggest that International level performance in non vigorous activities typically requires, on average, at least 10 years of preparation (Chase and Simon, 1973; Ericsson, 1996). The true meaning of the ten year rule has occasionally been misinterpreted as meaning ten years “experience” in a domain as being enough to acquire expert performance which is not the case. Therefore, in the case of International level dart players, the ten year rule will be investigated within the parameters of the first time they reported playing darts seriously to the date of their first International call up.

## **6.5. Activity chart.**

The activity chart completed by each participant included a taxonomy of weekly activities typical of those engaged in related to dart playing. Participants were asked to record their age at a particular year and to estimate how many hours per week during each year they would engage in each of the activities. The activity chart was similar to the one used by Ericsson et al., (1993) but was modified to incorporate activities related to dart players rather than musicians. A list of the activities included in the chart and an explanation of their relationship to dart playing activities follows;

### **6.5.1. Throwing darts with friends for fun.**

Throwing darts with friends for fun is where dart players would play matches against other people either at home but more often in a pub or club environment. This activity would be predominantly on a 'fun' basis but of the 36 players interviewed 4 men and 8 women did report this activity as an opportunity to work on their game. This particular activity for dart players relates closely to Ericsson et al.'s (1993) definition of 'play' which they claim does not fulfil the criteria for an activity designed purely to improve performance.

### **6.5.2. Participation in competitions.**

Participation in competitions is where dart players would travel to tournaments and compete against other dart players usually for money and/or world ranking points. This could be as an individual or as part of a representative team, nonetheless, even when competing as part of a team dart players always perform as individuals. This category

covered tournaments of three differing standards i.e., International standard, National standard and Regional standard. Both men and women of International/professional level would compete in predominantly International and National standard tournaments whereas men and women of intermediate/ county level would compete predominantly at National and Regional standard. However, it should be noted that there was some overlap in the early years of the International/professional level players whereby they started playing in National and Regional standard tournaments but progressed to a higher standard. Both men and women of International/professional level report playing in tournaments at predominantly International level (mainly those tournaments that carry World ranking points) from early on in their playing careers. An important point to note here is that although International/professional level women players engage in a higher standard of competitions as their careers progress, the standard would still not reach to the same level as for men. Due to the sheer numbers of men playing at a high level of performance, and the nature of competitions available for men, (i.e., invitational events), the competitive arena is far more intense for men than it is for women of International/professional level. Thus, women are not afforded an equal opportunity to compete at this consistently high level.

Playing in competitions relates closely to Ericsson et al.'s (1993) definition of 'work' for International/professional level dart players but could relate more closely to 'play' for the intermediate/county level players several of who reported 'enjoying' tournament play. Moreover, a relevant point to emerge from this data was that a number of players (50% of International/professional men) stated that competing in tournament play was the most effective method of learning to control the anxiety and nervousness associated with competition. They therefore viewed this activity as a form of practice! This view is

contrary to that of Ericsson et al., (1993) who clearly state that either 'work' or 'play' does not fulfil the criteria for an activity designed purely to improve performance.

### **6.5.3. Throwing darts for purposes of improving your performance (alone).**

Throwing darts for purposes of improving your performance alone is where dart players would engage in solitary activities where the primary objective was to improve their dart playing performance. The activities reported by all dart players, who engaged in this particular activity, showed very little variation. The activities included first, playing legs of 501 points down to a finishing double and working out their single dart average for each leg and the practice session as a whole. Secondly, going 'round the board on doubles' which is starting at the double 1 segment then, having hit it, move on to double 2, to double 3 and so on until every double including the bullseye has been hit. Finally, players reported practising two dart and three dart finishes, usually starting from 61 up to 170. Only when each standard dart finish was completed could a player move on to the next finish i.e., 61 completed by hitting treble 15 double 8, or single 11 bullseye. This particular activity for dart players relates closely to Ericsson et al.'s (1993) definition of 'deliberate practice' whereby the particular activities are engaged in solely for the purpose of improving dart playing performance.

### **6.5.4. Throwing darts for purposes of improving performance (with a training partner).**

Throwing darts for purposes of improving performance (with a training partner) is where dart players would engage in activities with a practice partner where the primary objective was to improve their dart playing performance. Again, the activities reported by all dart

players who engaged in practice with a partner showed very little variation. They played legs of 501 points down to a finishing double and calculated their single dart average for each leg and the practice session as a whole as their preferred mode of practice. In the case of International/professional level dart players practice partners were players of a competent standard but not of the same unique standard as the player whose primary objective it was to improve performance. In the case of intermediate/county level players practice partners were players of a similar standard as themselves, in fact, often they were other intermediate/county level players. As with the previous activity, this particular activity for dart players relates closely to Ericsson et al.'s (1993) definition of 'deliberate practice' whereby the particular activities are engaged in solely for the purpose of improving dart playing performance.

#### **6.5.5. Playing exhibition matches.**

Playing exhibition matches is where dart players are paid to make public appearances at pre-designated venues to play against a number of select players. The number of matches played are variable, as is the format, although it would usually be legs of 1001 points down to a finishing double. These matches carry no form of ranking points or prize money but are purely for the purpose of providing the opportunity for dart players from a particular locality to pit their skills against renowned experts. It is predominantly International/professional level players who engage in this activity although on occasions intermediate/county level players have reported engaging in this activity on an irregular basis. This activity comprises a significant stable contribution to the annual income of International/professional players as opposed to prize money from competitions which is by its nature variable and unpredictable. This particular activity relates closely to Ericsson

et al.,’s (1993) definition of ‘work’ but in the case of International/professional level dart players it was often reported as being an important form of practice.

#### **6.5.6. Playing local league/superleague.**

Playing local league/superleague is where dart players report playing in matches at a local/regional level. Players receive no form of payment for playing in these matches, or any competition affiliated to a particular league, which distinguishes league competitions from other forms of competitive tournaments. Local league/superleague matches are played on a weekly basis throughout the official dart playing season which runs from September to May each year, competitions affiliated to each league are played at the end of the season usually in May/June.

#### **6.5.7. Receiving Instruction.**

Receiving Instruction is where dart players would receive instruction, primarily during their initial contact with the sport, usually from parents, other family members, friends or peers. This instruction would take the form of showing them how to stand, the rules of the game and how to attempt the correct finishing shots. Much of the instruction would be rudimentary and learnt during the early stages of playing darts with the exception of learning dart finishes which would only be accomplished after extensive experience.

## **6.6. Statistical analysis of semi-structured interview data.**

Results from the analyses of semi-structured interview data are reported in sequential fashion in the forthcoming sections. First, biographical data such as age of players at the time of interview, starting age and career span are reported. Secondly, the ratings of practice on four separate dimensions, namely relevance for improving dart playing performance, how much physical effort practice required, how much concentration practice required and how enjoyable practice was are reported. Thirdly, variables investigated via the activity chart, relating to dart playing activities such as, playing in competitions, playing for fun, playing league, engaging in deliberate practice and playing in exhibition matches are reported. Finally, an investigation of the Ten Year Rule and its relevance to International/Professional level dart players is reported.



**6.6.1. Results of biographical data.**

Mean age, starting age and career span in years and corresponding standard deviations were calculated for both men and women dart players and reported in Table 6.6.1.1. As can be seen all aspects of the demographic data for men and women dart players across two levels of skill are similarly matched.

**Table 6.6.1.1. Mean age, starting age and career span in years, with corresponding standard deviations in brackets, of men and women dart players across two levels of skill.**

	<b>International Men</b>	<b>County Men</b>	<b>International women</b>	<b>County Women</b>
<b>Count</b>	12	12	6	6
<b>Age</b>	41.75 (6.26)	41.08 (6.95)	36.67 (6.15)	42.00 (5.51)
<b>Starting age</b>	16.92 (5.09)	17.33 (3.50)	16.84 (3.45)	21.50 (7.45)
<b>Career span</b>	24.83 (6.55)	23.92 (4.50)	20.17 (3.54)	20.50 (7.56)

When data were subjected to statistical analyses by way of 2 X 2 Factorial ANOVA there were no significant main effects between groups for age,  $F(2,32) = .960$ , NS, for starting age  $F(2,32) = .182$ , NS or career span  $F(2,32) = .150$ , NS. Moreover, there were also no significant interactions for age  $F(1,32) = 1.766$ , NS, starting age  $F(1,32) = 1.525$ , NS or career span  $F(1,32) = .096$ , NS.

**6.6.2. Results of ratings of dimensions of practice.**

Participants were asked to rate practice on four separate dimensions using a scale of 0 - 10, where 0 was low, 5 was average and 10 was high. They were asked to rate practice on relevance for improving dart playing performance, how much physical effort practice required, how much concentration practice required and how enjoyable practice was. The means and corresponding standard deviations of men and women dart players' ranking on three dimensions of practice are reported in table 6.6.2.1 The fourth dimension, relevance for improving performance, was rated as 10 for 100% of the participants. Should there be significant differences on these variables between groups then it could be argued that attitudes towards practice could have an affect on performance.

**Table 6.6.2.1. Means, with corresponding standard deviations in brackets, for the ranking of three aspects of practice, namely physical, concentration and enjoyable for men and women dart players across two levels of skill.**

	<b>International Men</b>	<b>County Men</b>	<b>International Women</b>	<b>County Women</b>
<b>Physical</b>	6.25 (2.34)	5.33 (2.81)	6.00 (3.68)	7.17 (2.48)
<b>Concentration</b>	8.75 (1.54)	6.33 (3.23)	8.00 (2.52)	8.17 (1.60)
<b>Enjoyable</b>	5.67 (2.57)	7.17 (3.43)	6.33 (4.03)	8.17 (2.23)

When data were subjected to statistical analysis by way of MANOVA Pillais criterion indicated no significant interaction  $F(3,30) = .99$ , NS, no significant effect for level of skill  $F(3,30) = 1.59$ , NS and no significant main effect for gender  $F(3,30) = .38$ ,  $p = NS$ . for any of the three aspects of practice.

### 6.6.3. Results of activity chart.

Mean accumulated number of hours and corresponding standard deviations were calculated for seven activities relevant to dart playing, namely playing in competitions, playing for fun with friends, playing league, engaging in solitary practice and practice with a playing partner, total deliberate practice (solitary practice and practice with a partner combined) and playing in exhibition matches as reported by men and women dart players across two levels of skill. These results are shown in tables 6.6.3.1, 6.6.3.2, 6.6.3.3, 6.6.3.4, 6.6.3.5, 6.6.3.6 and 6.6.3.7. Should there be significant differences in the accumulated number of hours engaging in any of these variables, across levels of skill or between genders, then one may argue these particular variables could have an effect on the acquisition of expert performance. The forthcoming analysis was by way of Multivariate analysis of variance (MANOVA), employing Pillais Criterion which is recommended for unequal groups. Post hoc analysis was also employed by way of Roy-Bargman step down F tests (applying Bonferroni correction) as this method addresses the problem of Dependent Variables which

are correlated. This is done by a method analogous to the testing of several Independent Variables in Multiple Regression via Hierarchical Analysis. The Highest priority Dependent Variable is tested in a Univariate Anova (using the appropriate adjustment for alpha) and the remaining Dependent Variables are tested in a series of ANCOVA's.

Table 6.6.3.1 shows the number of accumulated hours engaged playing in dart competitions and, as can be seen, throughout the career span from year 3 up to, and including year 10, both International men and International women report fewer

accumulated hours in this activity than county level men and women. However, by year 15 county level women report the lowest number of accumulated hours spent engaging in competitions, followed by International women, International women and County men respectively.

**Table 6.6.3.1. Mean accumulated number of hours engaged in playing in competitions, with corresponding standard deviations in brackets, at year 3, year 5, year 10 and year 15 into the careers of men and women dart players across two levels of skill.**

	<b>International Men</b>	<b>County Men</b>	<b>International women</b>	<b>County Women</b>
<b>Competition at year 3</b>	161.33 (198.61)	327.17 (413.99)	156.00 (135.60)	442.00 (657.55)
<b>Competition at year 5</b>	412.67 (347.58)	676.00 (695.89)	385.67 (279.26)	736.67 (1047.48)
<b>Competition at year 10</b>	1255.67 (536.63)	1614.17 (1406.99)	1200.33 (625.82)	1317.33 (1217.14)
<b>Competition at year 15</b>	2180.83 (808.64)	2545.83 (1971.16)	1940.33 (897.95)	1627.67 (1002.04)

When data were subjected to formal analyses by way of MANOVA, Pillais criterion indicated no significant main effects for number of hours engaged in competitions for gender  $F(4, 29) = .93$ , NS, no significant main effects for level of skill  $F(4, 29) = .88$ , NS and no significant interaction  $F(4, 29) = .36$ , NS. There was no significant relationship between the number of accumulated hours spent playing in competitions and single dart averages. Furthermore, null effects on the subjective reports for accumulated number of hours spent playing in competitions would suggest this particular variable is not a contributing factor in either the acquisition of expertise or gender differences in dart playing performance.

Table 6.6.3.2 shows the number of accumulated hours engaged in playing darts with friends for fun. As can be seen, throughout the career span from year 3 up to, and including year 10, Both International men and International women report fewer accumulated hours in this activity than county level men and women. However, by year 15 county level women report the lowest number of accumulated hours spent engaging in competitions, followed by International women, International women and County men respectively.

**Table 6.6.3.2 Mean accumulated number of hours engaged in playing for fun, with corresponding standard deviations in brackets, at year 3, year 5, year 10 and year 15 into the careers of men and women dart players across two levels of skill.**

	International Men	County Men	International women	County Women
Playing for fun at year 3	1323.83 (1554.38)	1018.33 (486.52)	1169.33 (577.92)	390.00 (274.67)
Playing for fun at year 5	2221.83 (2705.13)	1737.67 (810.59)	1984.00 (932.73)	632.67 (474.79)
Playing for fun at year 10	3595.50 (4817.52)	3202.33 (1320.82)	3499.00 (1908.94)	1170.00 (813.43)
Playing for fun at year 15	3944.33 (5030.85)	4237.00 (1759.94)	4105.00 (2344.71)	1394.67 (1015.56)

When data were subjected to formal analyses by way of MANOVA Pillais criterion indicated no significant main effects for number of hours engaged in playing for fun for gender  $F(4, 29) = .75$ , NS, no significant main effects for level of skill  $F(4, 29) = .75$ , NS and no significant interaction  $F(4, 29) = 1.81$ , NS. There was no significant relationship between the number of accumulated hours spent playing darts for fun and single dart averages. Furthermore, null effects on the subjective reports for accumulated number of hours spent playing darts for fun would suggest this particular variable is not a contributing

factor in either the acquisition of expertise or gender differences in dart playing performance.

Table 6.6.3.3 shows the number of accumulated hours engaged in playing league darts and, as can be seen, International level men report the lowest number of hours at each career stage from year 3 up to, and including year 15. Up to, and including year 5, International level women report a lower number of accumulated hours than either county level men or county level women until years 10 and 15 when county women report the lowest number of accumulated hours. County level men consistently report the highest number of accumulated hours spent playing league darts across all career stages from year 3 to year 15.

**Table 6.6.3.3. Mean accumulated number of hours engaged in playing league darts, with corresponding standard deviations in brackets, at year 3, year 5, year 10 and year 15 into the careers of men and women dart players across two levels of skill.**

	<b>International Men</b>	<b>County Men</b>	<b>International women</b>	<b>County Women</b>
<b>Playing league at year 3</b>	368.33 (283.48)	1003.17 (548.35)	832.00 (518.96)	962.00 (845.38)
<b>Playing league at year 5</b>	788.67 (410.55)	1869.83 (836.16)	1456.00 (846.82)	1638.00 (1364.25)
<b>Playing league at year 10</b>	1707.33 (843.69)	3852.33 (1356.26)	3206.67 (1603.98)	2981.33 (2212.95)
<b>Playing league at year 15</b>	2383.33 (1240.46)	6042.83 (1495.54)	4402.67 (1732.67)	3267.33 (2010.84)

When data were subjected to formal analyses by way of MANOVA, Pillais criterion indicated a significant main effect for number of hours engaged in playing league for

gender  $F(4, 29) = 3.97, p < 0.05$ , no significant main effect for level of skill  $F(4, 29) = 2.22$ , NS and a significant interaction  $F(4, 29) = 10.28, p < 0.0001$ . (see appendix 9 for graph of interaction). Post hoc analysis by way of Roy-Bargman stepdown F tests, applying Bonferroni correction, found significant interaction effects at year 15 into career  $F(1, 29) = 28.71, p < 0.0001$  and a significant effect for gender at year 15 into career  $F(1, 29) = 12.37, p < 0.001$ . There was a significant negative relationship between the number of accumulated hours spent playing league darts and single dart averages at year 3,  $r = -.39, p < 0.05$ , at year 5,  $r = -.35, p < 0.05$  and year 10,  $r = -.35, p < 0.05$  into career. There was no significant relationship between these two variables at year 15 into playing career. Furthermore, a significant main effect for gender and a significant interaction effect would indicate that playing league darts is a factor contributing to gender differences.

Table 6.6.3.4 shows the total number of accumulated hours engaged in deliberate practice and, as can be seen, International level men report the highest number of accumulated hours of deliberate practice at each career stage from year 3 up to, and including year 15. Moreover, International level women report higher levels of deliberate practice than County level men, who in turn report higher levels than County level women. This finding is consistent across career span from year 3 to 15.

**Table 6.6.3.4. Mean accumulated number of hours engaged in total deliberate practice (i.e., incorporating practice alone and practice with a partner), with corresponding standard deviations in brackets, at year 3, year 5, year 10 and year 15 into the careers of men and women dart players across two levels of skill.**

	International Men	County Men	International women	County Women
<b>Total practice at year 3</b>	1931.50 (1773.70)	663.00 (703.66)	1196.00 (1241.92)	372.67 (462.09)
<b>Total practice at year 5</b>	3573.00 (2812.204)	1304.33 (1410.80)	2097.33 (1872.20)	702.00 (778.79)
<b>Total practice at year 10</b>	8366.83 (4906.82)	2331.33 (2302.97)	5009.33 (2701.13)	1282.67 (1121.40)
<b>Total practice at year 15</b>	12838.83 (7779.57)	3269.50 (2916.43)	6491.33 (3298.69)	1612.00 (1430.14)

When data were subjected to formal analyses by way of MANOVA Pillais criterion indicated no significant main effect for number of hours engaged in total deliberate practice for gender  $F(4, 29) = 1.43$ , NS, a significant main effect for level of skill  $F(4, 29) = 5.36$ ,  $p < 0.01$  and no significant interaction  $F(4, 29) = .44$ , NS. Post hoc analysis by way of Roy-Bargman stepdown F tests, applying Bonferroni correction, found a significant effect for level of skill with International/professional players reporting a higher number of hours engaged in deliberate practice at year 10 into their career  $F(1,30) = 12.21$ ,  $p < 0.001$ . Pearson's Product Moment Correlation Coefficient revealed a significant positive relationship between single dart averages and the number of accumulated hours spent engaged in total practice (solitary deliberate practice and practice with a partner) at year 3,  $r = .33$ ,  $p < 0.05$ , at year 5,  $r = .38$ ,  $p < 0.05$ , year 10,  $r = .48$ ,  $p < 0.01$  and year 15  $r = .53$ ,  $p < 0.001$  into career. This correlation provides evidence that single dart averages have a



strong positive relationship with total deliberate practice. This finding, along with a significant main effect for level of skill, implicates total deliberate practice as playing a significant role on the acquisition of expertise amongst elite dart players. Significantly, the relationship between single dart averages and total deliberate practice becomes stronger as career span progresses.

Table 6.6.3.5 shows the total number of accumulated hours engaged in solitary deliberate practice and, as can be seen, International level men report the highest number of accumulated hours of deliberate practice at each career stage from year 3 up to, and including year 15. Moreover, International level women report higher levels of deliberate practice than County level men, who in turn report higher levels than County level women. This finding is consistent across career span from year 3 to 15.

**Table 6.6.3.5. Mean accumulated number of hours engaged in solitary deliberate practice, with corresponding standard deviations in brackets, at year 3, year 5, year 10 and year 15 into the careers of men and women dart players across two levels of skill.**

	International Men	County Men	International women	County Women
Solitary practice at year 3	1574.00 (1759.74)	533.00 (642.30)	650.00 (601.72)	364.00 (467.43)
Solitary practice at year 5	2853.67 (2841.47)	1109.33 (1366.53)	1256.67 (850.91)	606.67 (759.03)
Solitary practice at year10	6265.17 (4589.86)	1958.67 (2197.17)	3076.67 (981.36)	1144.00 (1116.25)
Solitary practice at year 15	9419.83 (6532.48)	2684.50 (2754.87)	3934.67 (1118.50)	1456.00 (1451.59)

When data were subjected to formal analyses by way of MANOVA, Pillais criterion indicated no significant main effects for solitary practice for gender  $F(4, 29) = 1.23, NS$ .

no significant interaction  $F(4, 29) = .715$ , NS but a significant main effect for level of skill  $F(4, 29) = 4.21$ ,  $p < 0.01$ . Post hoc analysis by way of Roy-Bargman stepdown F tests, applying Bonferroni correction, found a significant effect for level of skill with International/professional players reporting a higher number of hours engaged in deliberate practice at year 10 into their career  $F(1, 30) = 12.32$ ,  $p < 0.001$ . There was a significant positive relationship, by way of Pearson's Product Moment Correlation Coefficient, between single dart averages and the number of accumulated hours spent engaged in solitary deliberate practice at year 3,  $r = .34$ ,  $p < 0.05$ , at year 5,  $r = .38$ ,  $p < 0.05$ , year 10,  $r = .47$ ,  $p < 0.01$  and year 15,  $r = .53$ ,  $p < 0.001$  into career. Noteworthy, is that deliberate practice with a partner (reported next) revealed no significant relation with single dart averages, therefore the significant relationship found between total practice and single dart averages is due mostly to solitary deliberate practice.

Table 6.6.3.6 shows the total number of accumulated hours engaged in deliberate practice with a partner and, as can be seen, International level women report the highest number of accumulated hours of deliberate practice at years 3 and 5, followed by International men, County men and County women respectively. At years 10 through to 15 International level men report the highest levels of practice with a partner followed by International women, county level men and county level women respectively.

**Table 6.6.3.6 Mean accumulated number of hours engaged in deliberate practice with a practice partner, with corresponding standard deviations in brackets, at year 3, year 5, year 10 and year 15 into the careers of men and women dart players across two levels of skill.**

	<b>International Men</b>	<b>County Men</b>	<b>International women</b>	<b>County Women</b>
<b>Practice with a partner at year 3</b>	357.50 (534.47)	130.00 (236.22)	546.00 (652.59)	8.67 (21.23)
<b>Practice with a partner at year 5</b>	719.33 (786.38)	195.00 (386.68)	840.67 (1050.56)	95.33 (169.03)
<b>Practice with a partner at year 10</b>	2101.67 (2261.36)	372.67 (763.54)	1932.67 (1892.81)	138.67 (214.82)
<b>Practice with a partner at year 15</b>	3419.00 (3594.68)	585.00 (1101.78)	2556.67 (2488.28)	156.00 (243.90)

When data were subjected to formal analyses by way of MANOVA, Pillais criterion indicated no significant main effect for deliberate practice with a partner for gender  $F(4, 29) = .543$ , NS, no significant main effects for level of skill  $F(4, 29) = 2.40$ , NS and no significant interaction  $F(4, 29) = .798$ , NS. There was no significant relationship between single dart averages and the number of accumulated hours engaged in deliberate practice with a partner. This finding, along with null effects on the subjective reports for accumulated number of hours spent engaging in deliberate practice with a partner would suggest this particular variable is not a contributing factor in either the acquisition of expertise or gender differences in dart playing performance.

Table 6.6.3.7 shows the total number of hours, along with corresponding standard deviations, spent engaging in exhibition matches throughout a 15 year career span for men and women International/professional level players. As can be seen from the table. International/professional level men report the highest number of accumulated hours spent engaging in this particular activity.

**Table 6.6.3.7. Mean accumulated number of total hours engaged in exhibition matches, with corresponding standard deviations in brackets, during career span of 15 years for International level men and women dart players.**

	Total number of hours playing exhibition matches During career span of 15 years			
	Mean	Minimum	Maximum	Count
<b>International level men</b>	2064.50 (1731.36)	234.00	4784.00	12
<b>International level women</b>	472.33 (617.99)	0.00	1560.00	6

When data were subjected to formal analysis by way of one-way ANOVA a significant difference in favour of International level men was found for the total number of hours spent engaging in exhibition matches  $F(1, 16) = 4.65, p < 0.05$ . This particular variable was reported as an effective method of learning to control the anxiety and nervousness associated with competition and as an important form of practice by International/professional level players (as reported in section 6.5.5). Therefore, in view of these findings, playing in exhibition matches could play a significant role in maintaining an International/professional level of performance as well contributing to gender differences in level of skill.

**6.7.4. Ten year rule.**

Table 6.7.4.1 reports the total number of years, along with corresponding standard deviations, spent playing darts seriously prior to acquiring International level status for both men and women players. As can be seen from the table the shortest period of preparations required to attain International playing status is 4 years for both men and women, whereas the maximum time for women is 18 years and for men is 15 years. Means for both men at 7.33 years and women at 9.00 years fall short of the Ten Year Rule.

**Table 6.7.4.1 Mean number of years playing darts seriously, with corresponding standard deviations in brackets, before becoming an International level player for men and women.**

	International Level Dart Players			
	Mean	Minimum	Maximum	Count
<b>Men</b>	7.33 (3.11)	4	15	12
<b>Women</b>	9.00 (5.22)	4	18	6

This finding suggests that the 'Ten Year Rule' of preparation for expertise is not a consistent measure for elite dart players.

**6.8. Discussion.**

The present Chapter fulfilled the aim highlighted in the preface (see 6.1) which was, to examine a number of key factors identified in previously reported research by Ericsson et al., (1993). Particularly, the role of deliberate practice in the acquisition of throwing skill amongst male and female dart players. To investigate this factor ex post facto research by way of semi-structured interviews was carried out. Initially, demographic variables, namely; current age, starting age and career span were addressed. Results found no significant differences between groups on any of these variables, therefore eliminating them as factors responsible for differences in dart playing performance across levels of skill or gender. Of the three variables mentioned above the most frequently investigated in previous research of this nature has suggested a link between starting age and performance. The basis of this research stems from the idea that individuals who start participating in an activity at an early age will have engaged in more deliberate practice than those who started later (Ericsson et al., 1993) and, as a consequence, should have attained a higher level of performance. But for dart players at least this is not case, with the mean starting

age for International men and International women being similar, at just below 17 years of age. Noticeably, dart players appear to take up their sport somewhat later in life than players in many other domains. For example, in music, the mean starting age reported was 7.9 years (Ericsson et al., 1993), soccer, where the mean starting age was 5.5 years, and field hockey, where the mean starting age was 8.6 years (Helsen et al., 1998). More in line with the findings of the present study were the results of a sport specific test of Ericsson et al.'s (1993) theory of deliberate practice by Hodges and Starkes (1996). They investigated four groups of male amateur wrestlers and reported a mean starting age for all four groups of approximately 13 years of age. One argument to possibly account for wrestlers and dart players starting at a later age than participants in the previously mentioned sports and music, is that these activities are often part of the education curriculum, therefore children have the opportunity to experience them at an earlier age.

Results of the four dimensions of practice showed first, that all players rated practice as highly relevant for improving performance. Secondly, there were no significant differences between groups on their ratings for the dimensions of how much physical effort their practice required, how much concentration was required and how enjoyable the practice was. When means were collapsed across groups ratings (where 10 = high, 5 = average and 0 = low) for the physical dimension the mean was 6.2, for concentration there was a mean of 7.8 and for enjoyment a mean of 6.8. The findings from this study were in line with those found in previous studies. For example; the requirement of high concentration for practice, and that practice is highly relevant to the level of performance one may acquire, was strongly supported by Martial artists Hodge and Deakin (1998), Musicians (Ericsson, et al., 1993), Figure Skaters (Starkes et al., 1996) Wrestlers (Hodges and Starkes, 1996) and Soccer and Field Hockey players, (Helsen, et al., 1998). In relation to enjoyment of

practice, previous research has shown, that practice is not always perceived as an activity that is low on inherent enjoyment, as suggested by Ericsson et al., (1993), particularly when activities engaged in during practice routines are directly related to actual performance (Hodges and Starkes, 1996; Hodges and Deakin, 1998). However, as previously discussed (section 6.2.2), these studies did not capture the essence of what Ericsson et al., (1993) actually meant by deliberate practice being rated as 'low on inherent enjoyment' and therefore, their findings may not necessarily contradict those of Ericsson et al., (1993). For dart players, practice activities are directly related to those activities undertaken during actual game performance, therefore it is perhaps no surprise that the participants rated practice as above average on enjoyment.

Findings from analyses of the activity chart data found no significant differences between groups for playing in competitions, playing for fun or practising with a partner. Moreover, there was no significant relationship between these particular variables and single dart averages. These results are somewhat expected as, for example, in the case of playing in competitions both International/professional and intermediate/county level dart players would engage in this as an activity on a regular basis to compete for prize money. However, differences in the level of competition could be a more crucial factor. For example: International/professional players would play in predominantly world ranked International competitions and less national, regional or local competitions, whereas, for intermediate/county players, the reverse would be the case. In view of many of the International/professional players' attitudes towards competitive play, and its contribution to improving performance, this could be argued to have a significant effect on overall performance. Furthermore, playing in competitions relates closely to Ericsson et al.'s (1993) definition of 'work' for International/professional level players but could relate

more closely to 'play' for the intermediate/county level players several of who reported 'enjoying' tournament play. Moreover, an interesting point to emerge from this data was that several of the International/professional dart players stated that competing in tournament play (and exhibition matches discussed in the forthcoming section) was an effective method of learning to control the anxiety and nervousness associated with competition. They therefore viewed competition as a form of practice in itself! This view is contrary to that of Ericsson et al., (1993) who clearly state that neither 'work' nor 'play' fulfil the criteria for an activity designed purely to improve performance. In relation to playing for fun, again it is not surprising that no significant differences were found between groups. Darts has its roots firmly embedded in a social context. Elite dart players are typically introduced to playing darts in an informal, social environment whilst elite performers in other domains, namely; music and sport, may have their first point of contact with a particular activity in a specifically designed domain-related environment, i.e., a music school, gymnasium and/or athletics track. Therefore, elite dart players spend several years, prior to becoming elite, playing darts within a 'social type' framework. Arguably this could go some way towards explaining why there were no differences between groups for practising with a partner. When dart players decide to make a conscious effort to improve their performance beyond their current levels, the preferred method is to become isolated, thereby distancing themselves from the social context to engage in solitary deliberate practice. Interestingly it is this activity which revealed a significant difference between levels of skill (further details follow later in discussion).

Playing league darts was a further variable investigated via the activity chart. Findings revealed a significant negative relationship between the number of accumulated hours spent playing league darts and single dart averages. Moreover, a significant interaction



effect and significant main effect for gender would indicate that playing league darts is a factor contributing to gender differences. This finding reinforces the previous argument that, in order to improve dart playing performance, a player needs to isolate oneself from the social aspect of the sport in order to concentrate purely on those activities to be engaged in solely to improve performance. Clearly, as revealed in these findings, International/professional level men are the only group investigated here, that actually do this. With this in mind, one could argue that continually engaging in the 'social' aspect of dart playing, especially across a career span of several years, could actually be detrimental to improving performance, irrespective of deliberate practice. This is evident from data obtained from International/professional women whereby this group engaged in comparative amounts of deliberate practice as International/professional level men but higher amounts of accumulated number of hours playing league darts.

Significant differences between levels of skill were found for total deliberate practice (solitary practice and practice with a partner combined) and solitary deliberate practice, when analysed separately, with International/professional level players practising reliably more than intermediate/county level players. Moreover, there was a significant positive relationship between both of these variables and single dart averages, indicating that as practice increases so does dart playing performance. This finding supports one of the main tenets of Ericsson et al.'s (1993) theory whereby expertise is acquired through a vast number of hours spent engaging in activities purely designed to improve performance, i.e., deliberate practice. Somewhat surprisingly, the data revealed no significant gender differences in amounts of accumulated deliberate practice, therefore this variable does not account for the superior dart playing performance of men. One is then forced to address

alternative issues in an attempt to explain this disparity, such as the effects of socialisation, competitive match environment and audience effects as highlighted in Chapter 2.

The final variable investigated from the activity chart was the accumulated number of hours International/professional players spent engaging in exhibition matches. Men were found to report significantly more time engaging in this particular activity than women. Moreover, men also viewed exhibition matches as a valuable source of practice, particularly when they are against players of a competent standard. In this instance, they are competitive and involve a moderate level of anxiety because as professional players, paid to exhibit their superior skills, they are expected to win. One could view this scenario as a 'watered down' version of a real life competition situation, thus, enabling professional players to 'rehearse' for the real thing! The finding that women take part in significantly fewer exhibition matches than their male counterparts could arguably account for a) differences in performance due to less practice and b) inferior preparation in dealing with a competitive match situation.

Finally, what of the Ten Year Rule of necessary preparation for the acquisition of expertise? Previous researchers (Ericsson, 1996; Bloom, 1985 and Chase and Simon, 1973) have provided evidence in support of an important role of preparation in the acquisition of expertise, namely; at least ten years of preparation to acquire International level of performance. One must not confuse ten years of general 'experience' within a domain with ten years of 'preparation', which in this context means the time one spends engaging in those activities designed purely to improve performance with a view to attaining expert levels. The findings for International/professional level dart players falls somewhat short of the Ten Year Rule, with men acquiring International level performance

at a mean age of 7.33 years and women at 9.00 years. Moreover, there are large deviations from these means when one looks at the minimum and maximum years for both men and women. For example; of the 12 elite men in this study, four acquired International level status within 5 years or under whereas one player took 15 years. For the women, 2 elite players acquired International level status within 5 years or under, whereas one took 18 years. One would be wise to proceed with caution when proposing incontrovertible rules relating to the acquisition of, particularly, International level status mainly due to the subjective selection processes used in many sports which are a result of their dependence on the opinions of members of selection committees. International teams by their nature have limited places available, this along with changing standards within each sport can serve to promote or restrict the progress of individual competitors within that sport at any given point in time. Therefore, at best, the Ten Year Rule may be appropriate in other domains of human activity but not necessarily generalisable across all sporting domains.

#### **6.8.1. An evaluation of Ericsson et al.'s (1993) interview schedule.**

The semi-structured interview schedule used by Ericsson et al., (1993) was initially developed as a measure to investigate factors contributing to expertise among musicians. This schedule has since been modified, by contemporary researchers, with items specifically designed to tackle questions in domains other than music, including sporting domains. In order to adequately investigate elite dart players it was found similarly appropriate to modify particular sections of this schedule. For example, questions were incorporated into the interview schedule to elicit information regarding the micro-structure of practice, specifically in order to establish not only the number of hours spent engaging in practice but details of which particular activities and drills actually constitute deliberate

practice for elite dart players. Furthermore, information reported via the activity chart included dart related activities unique to elite dart players and integral to their professional careers, namely playing in dart competitions, playing league darts and taking part in exhibition matches. Arguably, an important finding of this current study is that Ericsson et al.'s (1993) argument for activities relating to 'work, play and deliberate practice' forming a distinct criterion does not hold true for elite dart players. For example, as mentioned previously, a number of dart players interviewed in this study viewed their work, namely, playing in exhibition matches and playing in competitions as a useful form of practice. Moreover, when examining the gender differences in performance for the International/professional level players a salient factor is the number of hours spent playing in exhibition matches, which is significantly greater for men. In addition, as mentioned in section 6.5.2., the competitive arena is far less intense for International/professional level women therefore the opportunity to perform at a consistently high level and, consequently, learning how to cope with the high levels of pressure that go hand in hand with intense competition are not readily available to women dart players. In the absence of significant gender differences in deliberate practice between International/professional level players the above factors could be argued to contribute to the significant differences in performance between these two groups.

Perhaps in the absence of any comparable detailed questionnaire or interview schedule, incorporating a qualitative and quantitative oriented methodology, Ericsson et al.'s (1993) interview schedule, in essence, captures the key factors relating to acquisition of expertise. Moreover, it is not over lengthy, has shown to be easily adaptable to suit several different domains and is relatively straightforward to administer.

However, upon reflection, there are suggestions that one may make for improvements. For example, Ericsson et al., (1993) did not differentiate between physical effort and concentration when interviewing musicians in their study. As mentioned in Chapter 3, section 3.3.2.2 this distinction was an important factor for later research (see Starkes et al., 1996), and indeed for research findings within this thesis. Therefore, it is important that future researchers planning to utilise this particular semi-structured interview schedule take this into account.

Several issues related to the acquisition of expertise and gender differences in target throwing and dart playing ability have been tackled in this thesis. The implications of the findings herein are now discussed in Chapter 7.

## **Chapter 7: General Discussion.**

Having access to a unique population of men and women dart players of various levels of national and International expertise, the main aims of this thesis were as follows. First, to examine the extent of gender differences in target throwing ability among men and women dart players of various levels of skill, both in the form of laboratory based experimental data and single dart averages. The results, as will be discussed in detail below, replicated previous research findings on children and naïve adults, namely, a significant effect was found for the superiority of men's performance at all levels of skill over matched women counterparts. Further findings revealed that significant differences between genders and across two levels of dart playing skill were eliminated when participants used their non preferred hand. The second aim was, after having established the single dart average as a reliable dependent measure, to explore the possible role that physical factors, namely, height and arm length, may play in the level of expertise one may acquire in dart playing. Findings revealed that, once these physical factors were controlled for, there were indeed still significant differences in performance between men and women in dart playing. Therefore, the final focus of this thesis turned to examining which factors may have contributed to gender differences in dart playing performance and differences between levels of skill. This was achieved by employing semi-structured interviews, specifically designed to elicit information regarding the developmental histories of elite dart players, along with their current habits, evaluations regarding practice activities and their affect on the acquisition of expertise.

This discussion therefore will, in the main, attempt to deliberate separately on the results of the experimental, and quasi-experimental studies reported in this thesis and as listed below.

This will be followed by an overall conclusion of the findings with the final sections offering implications of the findings herein and suggestions for follow-up research.

In brief, the aims of this thesis were met as follows;

- Experiments 1 and 1a aimed to examine the affects of gender and target throwing skill employing both men and women university undergraduates and elite dart players. For the elite dart players (Experiment 1a) level of skill was also investigated.
- Experiment 2 aimed to examine whether, under the same laboratory based conditions as Experiment 1a, gender differences and differences due to levels of skill, may still be observed if the non-preferred hand is used for target throwing.
- Study 1 aimed to examine the relationship between laboratory based target throwing skills and data from a 'real world' dart playing environment in the form of single dart averages
- Study 2 aimed to examine the extent of gender differences, using single dart averages as the dependent measure, across three levels of elite dart playing, namely. International/professional, intermediate/county and superleague/local.
- Study 3 aimed to examine whether, having controlled for purely physical factors namely, height and arm length, one may still find significant differences between

genders and across levels of skill, in target throwing and dart playing ability, as measured by single dart averages.

- Study 4 aimed to examine data collected via a semi-structured interview schedule, popularly used in previous research on the acquisition of expertise, in order to investigate possible contributing factors to target throwing skills and dart playing expertise between gender groups and across levels of skill.

### **7.1. Experiments 1 and 1a. Gender differences and differences between levels of skill in target throwing skills: evidence from the elite dart players and university undergraduates.**

The literature on gender differences in target throwing has reliably shown that men are superior to women in this activity, especially when naïve university students are involved (Watson and Kimura, 1991). Thus, the rationale for conducting Experiment 1 was not solely for the purpose of replicating previous research but rather, in part at least, to “pilot” the experimental setting and materials to be used when investigating elite dart players as participants in a laboratory setting. Moreover, it was pertinent although not crucial to this thesis, to compare the findings of a population of naïve university undergraduates with that of a unique population of men and women using data gathered under the same experimental setting. The overall “comparisons” of how the target throwing scores of men and women university students compare to the target throwing scores of elite dart players obtained under the same experimental setting were reported and indeed, an interesting pattern of results emerged. The results of Experiment 1 on university students confirmed



previous findings by researchers such as Watson and Kimura (1991) who, when using college students, found that men significantly outperformed women in a dart throwing task. They argued that the superiority reported for men on this type of motor task did not appear to be an artefact of differences in physique or athleticism, but were more likely to be related to the already acknowledged male superiority for spatial processing. Whether the latter explanation accounts for differences between genders remains open to debate. However, what is noteworthy here is that a “mirror image” of performance differences was found for elite men and women dart players, i.e., male university students and elite dart players were significantly more accurate than female students and elite players regardless of their level of skill. Thus, the magnitude of between gender differences seems to have remained the same regardless of years of training, competitive performance and professional standing.

Further interest in this “comparison” of naïve versus elite performance is in the responses to questions asked before experiments 1 and 1a. For example; when questioned on their perception of task difficulty women perceived the task as being significantly more difficult than did men. Moreover, men reported themselves as being more accurate than women and more successful than women in a competitive situation. These findings are made even more interesting due to a high percentage of participants reporting the task as being perceived as 'neutral', in other words not gender-typed. But, noteworthy, is that target throwing was perceived as a female oriented task by only 2.5% of all participants (N = 88 in Experiments 1 and 1a). Moreover, all those participants who rated target throwing as a female oriented task came from the naïve group. This finding, in conjunction with a significant male superiority in target throwing, could arguably lend support to previous researchers who have found that women, when engaging in tasks perceived as not

stereotypically feminine in nature, can experience gender-role conflict which has a detrimental effect on performance (Guillet et al., 2000). Following the findings of Experiments 1 and 1a, and with particular focus on the responses to the short questionnaire, one could speculate on the implications for the sport of darts as follows. First, attitudes to support the notion that darts is not a sport generally played by women still prevail in naïve participants. Moreover, there appears to be no change in this perception even when players become elite performers and have accumulated years of experience in a competitive dart playing environment. Secondly; although over the past two decades, darts has emerged as a highly publicised televised spectator sport (second only to fishing as the UK's most popular participant sport) its image as a pub game, with its roots firmly embedded in a social context remains fixed. Not only does this serve to reinforce the image of darts as a stereotypically 'working class' sport, but also serves to strengthen the misconception of darts as a 'masculine' activity, thus, creating psychological barriers for women participants (see section 7.6 for further discussion on this point) and for related arguments on the psychological consequences of gender-stereotyping see Knight and Giuliano, (2001) and Roger, (2002). Whilst the 'new' breed of young dart players now have role models who are millionaire TV celebrities, the popular media still prefer to focus on the 'old' breed of dart player who emerged from the public bar to find fame and fortune on the oche. The sport of darts generally, and women participants in particular, could surely benefit if contemporary elite dart players were portrayed in a positive light, being recognised as highly skilled, highly competitive, dedicated sports 'men and women. This would serve to eradicate the negative stereotyping that continues to persist in the media coverage this sport.

## **7.2. Experiment 2: Gender differences and differences between levels of skill amongst elite dart payers in target throwing when using their non-preferred hand.**

When Watson and Kimura (1989) asked college students to throw with their non-preferred hand they still found a significant male superiority. Whilst in contrast a recent study (Barral and Debu, 2002) reported differential effects of aiming performance for 5 year old boys and girls, with boys reported to be more affected in their accuracy when using their non-preferred hand. Such a contrast in findings, whilst of interest from a developmental perspective, still falls short of explaining what may happen if men and women with years of training in target throwing with their preferred hand attempt to throw with their non-preferred hand. In Experiment 2 of this thesis results showed that not only were significant effects for gender eliminated when participants used their non-preferred hand but there was also a null effect for level of skill in target throwing accuracy. When reporting significant differences amongst college students using their non-preferred hand, Watson and Kimura (1989), along with other researchers (Wild and Payne, 1983), made a number of speculations as to the reasons gender differences were found. These ranged from an historical basis of gender roles to differences in purely biological and visuo-spatial abilities. For example; Watson and Kimura, (1991) suggest the gender differences found in their research could possibly be related to the 'known male superiority for spatial processing' (p. 375 ). In fact, researchers Brouchon et al., (1984) and Stelmach and Larish (1980), suggest such differences could be discussed within the conceptualisation of 'intrapersonal' and 'extrapersonal' space (see section 2.3.6). In a further speculation of gender differences, Watson and Kimura (1991) argue that gender differences in throwing

tasks are an artefact of the historical division of labour between the sexes in hunter-gatherer times. "From an ethological perspective, it is not implausible that this dissociation of sex differences is related to the differential division of labour between males and females in the course of hominid evolution. For instance, amongst 224 present-day human societies, hunting fishing and trapping of small animals are almost exclusively male occupations, whereas weaving, sewing and food gathering and preparation are predominantly performed by women ..... An evolutionary division of labour thus may have selected for differential patterns or abilities between sexes: extrapersonal spatio-motor accuracy in males, and intrapersonal motor accuracy in females" Watson and Kimura, (1991). Whether such conclusions are true will of course be the subject of further speculation not within the scope of this thesis. However, the important point here is, that in Experiment 2 of this thesis, women at a lower level of skill are as accurate with their non-preferred hand as men of a higher level of skill, i.e., differences between genders and across levels of skill are eliminated. Clearly male superiority for spatial processing was diminished when their non-preferred hand was used. Hence, there are clearly reasons to believe that factors, other than those highlighted above, may be responsible for discrepancies found in target throwing ability, at least in so far as a population of elite dart players are concerned. Could practice be one such plausible factor which could account for gender differences and differences in level of skill? Indeed, an alternative, yet somewhat related perspective, is that in today's society women engage in several sporting activities that were previously viewed as exclusively male, i.e. football, rugby and boxing. As a consequence there is evidence to show that women's measures of performance, i.e., times and distances, are improving at a faster rate than men's, which further demonstrates the narrowing of the gender gap. The argument here is that, as general everyday tasks become less gendered , thereby closing the gender gap, there may ensue an equalising effect on

tasks involving spatial processing. This could account for the null gender effect found among elite dart players when using their non-preferred hand.

However, having made this argument, one needs to attend to the issue of *quality* of practice as another contributing factor. Perhaps, whilst it is true that when women take on a male oriented task the gender gap may narrow, there are also indications that what may predispose one's levels of skill in throwing is the nature and quality of practice. This issue was investigated and reported in Study 4 of this thesis and will be debated in greater length later in section 7.5. On close examination of the interview data one finds there are no significant differences between men and women in the reported number of hours they engage in deliberate practice, only significant effects for level of skill. Therefore, on the basis of these findings, one could argue that the effects of practice, with the preferred hand at least, are more beneficial to men than women and this effect is not based purely on the quantity of practice engaged in.

On a final note for this section, there is arguably a more straight forward solution to unravelling the latter issue, namely; one could ask elite dart players to engage in practice, with their non preferred hand, under controlled experimental conditions. This would enable researchers to examine whether the same superiority for men, and differences between levels of skill, may still be observed. However, due to the nature of this population, for practical reasons this would be difficult, if not impossible to achieve. Most of the participants from Experiment 2 made it clear they would not engage in such an experiment as they believe it could have a detrimental affect on their individual practice regimes and, consequently, an affect on their performance. Such considerations have led one to explore alternative measures of performance for an elite population of dart players. This was partly the motivation for focusing on single dart averages as a measure of performance as this

would not necessarily entail active participation of individuals. Therefore, the rationale for using single dart averages was to utilise a measure of actual game performance, as opposed to a measure based on target throwing in a laboratory based setting. Thus, single dart averages emerged as the focal point at this stage of the investigation. However, an important issue was to ascertain if a strong relationship exists between single dart averages and dart throwing measures taken in a laboratory setting. Indeed, if there is a strong relationship one may argue that single dart averages, taken from a 'real world' naturalistic setting are as reliable a measure in studies of dart throwing as a measure taken when inviting individuals to perform in the laboratory. A further implication of such a relationship was to conclude that perhaps a major component of dart playing performance rests on how good one could perform in a target throwing task. Moreover, it also implies that, perhaps, other factors such as strategic components, variables due to crowd effect or anxiety may have little significant effect on single dart averages. The results of such a correlation are discussed next.

### **7.3. The single dart average as a reliable measure of dart playing performance.**

The results of Study 1 found support for a significant relationship between single dart averages taken from a 'real life' competitive match environment and target throwing scores taken from a laboratory based setting. However, the extent of the relationship between target throwing scores and single dart averages was stronger for men than women dart players. This could be an indication that factors other than target throwing skills have a greater influence on women's performance when compared to their male counterparts. This

significant relationship between single dart averages and target throwing thus makes dart playing an attractive sporting activity for understanding issues related to gender differences and within a particular gender groups' differences in target throwing. The finding that men's, rather than women's, target throwing scores correlate in a stronger fashion with their single dart averages may suggest that, for men, factors associated with the competitive arena, such as crowd effect or competitive anxiety, have less of an effect on target throwing ability than for women. On the other hand, the fact that women showed a weaker relationship between their single dart averages and laboratory based target throwing scores could indicate that factors associated with the competitive arena, as mentioned above, may have a detrimental affect on the performance of women. With this in mind, Study 2 aimed to investigate between gender differences and differences across three levels of skill at three different types of competitive venue, using single dart averages as a measure of performance, the expectation being that a strong gender difference would, again, emerge showing superiority for men. However, it was also important to examine whether there are any possible interaction effects, namely; are there differential effects due to the nature of the competitive arena, according to gender group and level of skill? This was investigated in Study 2.

In Study 2 gender differences in dart playing performance across three distinct levels of skill i.e., International/professional, intermediate/county and superleague/local. were investigated. Results were as expected with men showing reliably superior performance than women at each level of skill. Moreover, men's performance at International/professional level was reliably superior to that of men at intermediate/county level, who in turn were superior to men at superleague/local level. Interestingly this trend was not mirrored by the data for women where, although intermediate/county level women

were superior to superleague/local level women, International/professional level women were not reliably superior to intermediate/county level women. Moreover, men's performance at all three levels of skill exceeded the performance of the women players at the highest level i.e., International/professional level. These findings provide evidence for women's performance following a less predictable pattern than the performance of men. Of particular significance is the interaction effect reported in Study 2 (see appendix 8 for graphic display of interaction). Whilst differences in single dart averages between genders are similar at either end of the performance continuum, i.e., men are approximately 9 points superior to women at superleague/local level and 10 points superior at International/professional level, the differences are smaller (approximately 7 points ) at the intermediate/county level. Two points are noteworthy in relation to this finding. First, although women start at a lower level of performance than men, their improvement is greater by the time they reach Intermediate/county level, improving by over 3 points on their single dart average, whilst men improve by less than 2 points across the same stage. Thus, at the intermediate/county stage men's and women's performance is at its most congruent. Secondly, at superleague/local level, men and women play separately, for teams represented exclusively by the same gender, usually in a local unthreatening environment in front of a small audience. Whereas, at intermediate/county level women play alongside men in the same playing arena, usually somewhat larger than at superleague/local level but nonetheless still with a relatively small number of spectators. Arguably, these findings could lend evidence to suggest that women's improvement in dart playing performance is best served by a small, less threatening environment as their performance appears to improve steadily until the playing arena gets bigger, more competitive and with a much larger audience. Between intermediate/county and International/professional level, where the playing arena's host audiences counted in the thousands, women's performance plateau



shows very little improvement (approximately 1 point on their single dart average). In contrast men's performance between the same two stages shows its greatest improvement of over 4 points on their single dart average. Thus men's performance reliably improves as the playing arena becomes larger and more competitive, including an evaluative audience. Apparently this is not the case for women. Although this finding cannot account for the gender differences in dart playing performance observed at the lower end of the performance continuum, i.e., superleague/local level, it could account for the slower rate of improvement in performance, which is evident by the wider gap in performance between International/professional men and women at the highest level of the performance continuum.

Another noticeable aspect of changes in dart averages across different levels of skill are those between gender groups, specifically, how men show slower improvements at the intermediate stages, but, nevertheless show a marked increase in performance between the intermediate and highest level. This reflects an upward trend whereby performance appears to increase steadily with time and experience. In contrast, for women, performance appears to 'plateau' at the intermediate stage with no noticeable progress observed hereafter. Such considerations may have implications for a possible gender difference in skill acquisition and plateau of learning that may be specific to target throwing and dart playing. Arguably further research is needed for one to pursue these latter claims.

#### **7.4. Eliminating physical attributes as contributing factors.**

One of the confounding variables when making direct comparisons between men and women's performance in sporting events is the obvious difference in physical attributes between the two groups. Thus, whilst it is inappropriate to, say, make a direct comparison between the running times of men and women as a measure of their performance, at least in target throwing, physical differences could be controlled for. Study 3 of this thesis investigated whether purely physical attributes, namely, height and arm length could have a significant impact on target throwing skills and single dart averages. On close examination of the data of a population of intermediate level dart players ( $n = 80$ ) one's physique was found to have no significant effect on the level of dart playing performance one may acquire. In fact, differences in dart playing performance were fully explained by normal gender differences rather than factors relating to arm length and height. These findings lend support to previous research reported by Watson and Kimura (1989) and Watson and Kimura (1991) whereby significant gender differences, in favour of men, found on two target-directed tasks, i.e., intercepting and throwing; were not accounted for by differences in physique or athleticism. Noteworthy here, is that should one look at other precision target sports, namely; Rifle Shooting, Clay Pigeon Shooting and Pistol Shooting, gender differences in competitive performance are less stark (National Rifle Association of GB, 2001; Clay Pigeon Shooting Association, 2001; Great Britain Target Shooting Federation, 2001). Moreover, in some sports namely Ten Pin Bowling (Thomas, Schlanker & Over, 1996 and Professional Women's Bowling Association, 2000), Archery (Nelson & MacNee, 1996) and Croquet (Croquet Gazette, 2000) it is possible find samples of women and men that are matched for equivalent performance. Even in sports where, on the face of it at least, gender differences in physique could play a crucial role, namely: 3 day eventing and

show jumping, performance cannot be reliably predicted by gender (British Show Jumping Association, 2000). Important to note here is that all of the above mentioned sports allow mixed competition i.e., women compete alongside men in many competitions. Arguably then, women have to strive to achieve the highest standards in order to be successful, unlike sports where competition is segregated according to gender, where standards and competitive goals are set by fellow women. Thus, one may argue here that this supports evidence gathered from elite dart players highlighting the benefits of integrated competition reported in section 7.3. Furthermore, sports such as those related to Equestrianism are, arguably, less subjected to gender stereotyping, even socially desirable for women to participate in, therefore reducing gender role conflict (see section 2.3.3). Moreover, the success of women has long been established in these sports. Therefore, one could argue that a reduction or shift in the process of gender socialisation could facilitate the performance of women dart players, as well as those competing in many other sports.

### **7.5 Results of interview data and implications for the effect of deliberate practice.**

Within the scientific literature there has been no reported systematic research on how a population of professional dart players perform under laboratory conditions and respond to research questionnaires. This is perhaps, in part, due to the impracticality of involving 'elite level' dart players in systematic research and partly due to ethical considerations. It is however, quite possible to design carefully planned experimental research involving world class dart players. Indeed, at the initial stages of this investigation a number of research scenarios were entertained. For example; what would be the effects of laboratory controlled experiments on practice with the non-preferred hand? Would the null effect found between genders differ significantly? On other related notes, taking into account the

importance of cognitive and strategic issues, as argued by researchers such as Chase and Simon (1973) and Charness (1989), what would have happened if the sequence of numbers on the dartboard were changed? For example, instead of the double 20 being at the top of the dartboard it was placed at the bottom, or an alternative unfamiliar position. Would this manipulation have an effect on professional players performance, eliciting a significant decrease, or even increase, in their level of performance? Or would it have a significant impact on the gender differences reported herein? Such findings could add to our knowledge of how particular manipulations upon the 'context' of an environment can affect the strategic and cognitive aspects of elite performance.

However, it was soon apparent that; first, it was not practical to involve professional players in numerous experimental investigations. Secondly, it was not ethical to interfere with the well rehearsed and crucial practice regimes of professional dart players by asking them to engage in unnecessary practice with their non-preferred hand or to perform dart throwing tasks within an unfamiliar or “unusual” context. Therefore, the idea of partly engaging in a non-experimental research methodology at the onset of this investigation was, mainly due to the above factors. However, the choice of using an adaptation of Ericssons et al.'s (1993) semi-structured interview schedule for this latter stage of the investigation was due to the widely cited and well respected series of previous research that had also employed this material. Arguably, even within such a non-experimental approach, a number of considerations had to be met. Interviews had to be carefully arranged, ensuring the confidentiality of information maintained (hence no raw data is reported here as it may be linked to named individuals). Whether using data obtained from semi-structured interviews would give answers to the very many questions that one could raise in relation to the development of expertise or gender differences amongst elite dart

players is, perhaps, ambitious to say the least. Whatever information, however, one might elicit from an elite group of dart players, within the limitations of ethics, practicalities and the absence of previously reported studies, would arguably be cherished for its individual uniqueness and used as a source for follow up research or comparisons with parallel studies. With these thoughts in mind the final study of this thesis (Study 4) investigated, via quasi-experimental methods, the developmental histories of elite men and women dart players and, in particular, the role of deliberate practice in the acquisition of expertise. Both men and women, players across the two levels of skill investigated, were matched on demographic variables namely; current age, starting age and career span. Therefore these variables had no bearing on the results found. On examination of variables relating to dart playing only two of those investigated namely; playing league darts and deliberate practice were found to have significant effects. First, for playing league darts a significant interaction effect and a significant effect for gender emerged at year 15 into the playing career. This interaction shows that whilst womens' participation in the number of accumulated hours playing league darts gradually increases over time, regardless of level of skill, there is a marked decline of engagement in this activity for International/professional level men. This finding could suggest that this group gradually break away from the social context of the sport, moving toward a shift in attitude from social activity to profession. This particular dart playing activity could best be related to 'play' within the parameters of Ericsson et al.'s (1993) theory.

Secondly, solitary deliberate practice and total deliberate practice (solitary deliberate practice and practice with a partner) were shown to have significant effects for level of skill only, with International/professional level dart players engaging in a higher number of accumulated hours of deliberate practice over their career span. Moreover, these

differences start to emerge following year 5 into their careers, reaching significance by year 10, with differences not reaching significance at year 15. Of further interest, however, was the significant correlation between single dart averages and accumulated number of hours spent engaging in total deliberate practice and solitary deliberate practice (this significant relationship is due mostly to solitary deliberate practice as reported in section 6.6.3). Moreover, as the significant differences between the number of hours engaged in deliberate practice for level of skill start to emerge from years 5 to 10 of their playing career, and as there is a strong relationship between single dart averages and number of accumulated hours spent practising at career year 15, there is substantial evidence to suggest that the role of practice in the acquisition of expertise is indeed important.

## **7.6 Implications of the current research.**

The implications of this study in relation to gender differences and the acquisition of expertise in target throwing and dart playing are discussed in the following sections.

### **7.6.1 Contribution of the current research to gender differences in throwing skills.**

The general consensus of the literature review reported in Chapter 2 was, with the exception of research on clumsy children (Sugden and Sugden, 1991; Sims, Henderson, Morton and Hulme, 1996), where boys outnumber girls in motor disability, one of almost universal agreement that, boys and men, significantly out perform girls and women on measures of throwing skills (Morris et al., 1982); Halverson, et al., 1982) and Hoffman et al., 1983). However, what also emerged from this literature was there appears to be no universal agreement as to which factors contribute to such differences. Suggestions as to the crucial variables accounting for gender differences in throwing skills have ranged from

extreme biologically based factors to those more attributable to the environment. Most of which remain the topic of debate by various researchers today. The present findings indeed substantiate the claim that significant gender differences in dart throwing skills exist and these differences were shown to extend to a population of elite dart players. To this end, the universal agreement of the reported literature in Chapter 2 has been supported. Did, however, the present findings on an elite population reveal anything about which factors are responsible for gender differences in throwing skills? Perhaps, but with some limitations. The fact that using the non-preferred hand significantly eliminates gender differences is perhaps one finding that could be debated by various researchers as evidence more in support of non-biological factors responsible for gender differences. However, the findings that women engage in the same amount of practice as men, but still show significant differences in target throwing and dart playing, may render the “environmental” argument as also invalid. It is here that perhaps one could begin to speculate on profiling a more detailed “route” to perfection of throwing skills and dart playing for men and women. A route that is not just based on how much one engages in practice (or whether they are born with specific talents related to throwing), but more so on what happens in the process of engaging in target throwing tasks and professional dart playing. For example, previous research has shown that, in a dynamic team sport setting (Soccer), multiple goal setting strategies do have an impact on performance outcomes, Filby, Maynard and Graydon, (1999). Perhaps it is the case that when women dart players engage in practice they do not use such goal setting strategies, hence, do not obtain maximum benefit from their practice regimes. The features of this route could also take into account a host of “environmental” factors, ranging from the role early school education plays in encouraging initial interest in sporting activities, what motivates one to succeed, the affect of media interest and, at the highest level, how sponsorships dictate the structure of the sport.

Perhaps boys, from a very young age, tend to engage in the type of playful activities that promote those skills required in later life for dart throwing, and in fact learn these skills more quickly than girls (Halverson, et al., 1982). Hence, boys have early acquired attributes crucial to the development and acquisition of expertise in dart playing. Consequently, given that young men have initially, a keen *interest* in the sport, the *opportunity* to compete and arguably most important, the *motivation* to succeed, their developmental history and the structure of the sport as it stands today, allows scope for them to attain the highest level of performance. With lucrative sponsorships available to the world's best players, several televised tournaments world wide offering recognition for one's endeavours and an enviable lifestyle what more incentive would one need to engage in the vast amounts of deliberate practice necessary to succeed!

For young women, however, the route is not so clear. In contrast to young boys, the playful activities of girls arguably do not encourage or enhance the development of those throwing skills that are required in later life to become experts, comparable to men, in a throwing task, i.e., dart playing. Although the literature reviewed revealed an underlying trend which suggested that age, rather than gender, was a significant factor relating to throwing tasks during these early years, alternative research also suggests that early development of motor co-ordination could be essential for later success in skills for which this particular aspect of development is reliant (Glassow and Kruse, 1960). Later research (Halverson, et al., 1982) also had important implications for the role of development when they found that, even as early as the 7th grade, girls were 5 developmental years behind the boys in tasks involving the overarm throw. Moreover, self-reports suggested that boys had previously participated in more overarm throwing activities than girls. Arguably then, girls do not start off on their



dart playing careers on an equal footing, with the skills they bring into the sport underdeveloped in comparison to their male counterparts. This point is further enforced by the findings of Study 2, whereby significant gender differences exist among superleague/local level dart players who are at the onset of the dart players careers. Perhaps until these developmental factors are addressed women will never reach the standards acquired by men.

Returning to issues related to the 'adult' environment, it is clear that although many women have an *interest* in the sport of darts and, as revealed in this study, are prepared to engage in vast amounts of deliberate practice to improve their performance, the opportunity to compete on an equal footing with men is not available. Even for those elite women dart players who overcome the psychological barriers of acting outside of their expected gender role by competing in, what is still regarded as, a predominantly masculine domain, the opportunities are unequal to those available to their male counterparts. Professional darts in the UK is indeed male dominated. Until there is a change from within the organisation of the sport, providing opportunity for all aspiring dart players and not opportunity based on gender, women will always be regarded as bridesmaids, never the bride!

### **7.6.2. Contribution of this research to the development of expertise in sport.**

One of the key issues discussed in Chapter 3 was how research in sport, based on cognitive psychological assumptions pioneered by the work of Charness, (1976), has gained considerable popularity. However, it was also argued that research on the development of expertise in a vast majority of sports has difficulty in untangling the contribution of purely cognitive/strategic factors as opposed to the contribution of those more physical variables. One salient point of the research on dart playing expertise was that strategic variables play a more minor role in the level of performance one may acquire (see section 3.1 for the robot scenario). The finding that level of skill in dart playing is heavily dependent on deliberate practice has strong implications for the role of this variable in the development of expertise in dart playing. However, this does not imply that “strategic” factors may never play a role in dart playing. Indeed, it is important to define what is meant by “strategic”. The type of strategic factors referred to in the context of this discussion are of a more "indirect" nature as opposed to those highlighted amongst Chess players. Charness, (1976), when defining *strategies* in chess, would make reference to factors such as greater ability for higher level problem solving, an ability that, when considering a game such as Chess, should have a direct relevance to task performance. Therefore these strategies could be viewed as "direct" strategic processes. For example, Chess Grandmasters could re-build a game from memory far more accurately and perhaps with greater speed than their lower ranking counterparts. Grandmasters may be shown to have a more efficient memory capacity thanks to their ability to process information in larger chunks and more rapidly. Perhaps differences in cognitive functioning could be found across levels of skill, or indeed between genders, among dart players. Nevertheless, it argued here (and in section 3.1) that the essence of expert performance in dart playing is the ability to be accurate in purely

target throwing, with "direct" strategic factors playing a minimal role. However, perhaps a more appropriate line of enquiry for future researchers may be to investigate the role of what one could label "indirect" strategic factors. These strategies would be more tactical, psychological and individualistic in nature. For example, in some instances when players have the option to throw first in a match they choose to throw second, which often serves as a psychological ploy against their opponents. Perhaps an investigation of such factors may prove fruitful in contributing to the research reported in this thesis.

### **7.7. Suggestions for follow up research.**

Research based on evidence from a population of elite dart players would most certainly benefit from future investigations of a new generation of elite dart players both in terms of laboratory based performance and responses to questions asked using a similar interview schedule as used in the present study. Most certainly, with changes in gender roles in sporting participation, not only the number of eligible world class women whom one could approach will increase, but as importantly, there may be indications that comments such as "darts is a man's game" may be overshadowed by the greater success and more involvement of women in this arena.

Indeed, this study has pioneered the introduction of the single dart average as a rich source of archival data that could be utilised in any future investigation between men and women of different levels of skill and professional experience. This is particularly pertinent when one considers that for practical and ethical reasons it is often the case that other forms of data are not viable. Any future studies using the single dart average of forthcoming generations of dart players may reveal interesting findings. One may speculate that, if the

significant historical improvements in world records and performance criteria of men and women from various sporting arenas is to be taken as a valid argument, there are reasons to believe that significant differences, by way of improvements between dart averages, obtained from various generations of players will emerge. However, what would be of great interest here is whether there will also be a point in time when there will be no significant difference between men and women in their single dart averages. In the present study it was reported that International/professional men significantly outperform their female counterparts in dart playing. Moreover, level of skill was a more significant predictor of performance, as measured by the single dart average, for men than for women of various levels of skill. A study investigating a generation of 21<sup>st</sup> century dart players, however, may report data both on the basis of a laboratory based throwing experiment, or in the form of single dart averages that may refute the findings of this study. The present significant gender differences in target throwing and single dart averages between men and women across all levels of skill and competitive venues may be less noticeable, if not eliminated, in future reported studies. Furthermore, there may be a greater tendency for findings to show a more reliable and predictable pattern of performance in relation to levels of skill, not only for men but for women also. Additionally there may be interesting observations made by correlating single dart averages and target throwing data obtained from future generations of elite dart players. Whilst the present study reported a stronger relationship for men than for women, it is just possible that equally strong correlation's could be revealed between the two sets of scores for both men and women players in the future. This may signify that perhaps there has been a shift towards more congruity in performance for both men and women regardless of whether they are taking part in purely target throwing in a laboratory setting or performing in a competitive situation.

Perhaps the influence of “environmental” factors, as mentioned previously, namely, the perception of gender roles and gender identity, has a part to play if any discrepancy is found between data from the present study and that obtained from future research. One may hope that for future generations a shift in these social constructs will break down the psychological barriers often affecting women dart players of today. Of course, any narrowing of the gap for future players across differing levels of skill and between genders could also be due to changes in practice regimes and the nature of practice *per se*! A generation of women who may have bridged the gap in performance with their male counterparts may show evidence of engaging in quantitatively or qualitatively different practice routines to their predecessors. If this were the case, it would further strengthen the role of practice as a key factor in the development of expertise. However, the answers to these latter questions are reliant on comparable research, involving men and women dart players of a future generation, of various levels of skill, using the same interview questionnaire and experimental research as employed in the present study.

## **7.8 Concluding remarks . . . . .**

One could perhaps visualise the nature of this investigation as taking snap shots of the present and past history of men and women dart players at various levels of professional standing. The snap shots taken were by no means ideal and, at many times, restricted by what one was *able* to capture and what one would *ideally* like to capture, due to practical and ethical boundaries. What is captured, however, is the performance, thoughts and reactions of an elite generation of 80’s and 90’s dart players. A generation in which many aspects of sporting behaviour have gradually broken the barriers of gender stereotyping, attracting lucrative sponsorships and significant media attention. Arguably, the men and

women in this study are the 'pioneers' of modern dart playing. A generation of sportsmen and women at the onset of, and in a large way responsible for, the globalisation of their sport. Regardless of whether future researchers, targeting “elite” dart players following the same route as the present investigation, will report findings to substantiate or refute the findings herein, it is hoped that this research has served to provide an invaluable source of information. Information that perhaps may be used as a benchmark for researchers of the 21<sup>st</sup> Century in their quest for a better understanding of factors contributing to levels of skill and gender differences in the development of target throwing and dart playing.

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# APPENDICES

**Appendix 1: Questionnaire used for undergraduates in Experiment 1.**

GENDER: male    female    AGE IN YEARS:

1. *Have you previously played darts?    Yes    No*

    If yes;

    1x month    1x year    less than 5 times ever

2. *Do you regularly engage in a sport activity?    Yes    No*

    If yes which sport? \_\_\_\_\_

3. *Do you consider target shooting?    Male oriented    Female oriented    Neutral*

4. *How confident do you feel of hitting the target out of 12 trials?*

    1    2    3    4    5    6    7    8    9    10    11    12

5. *If the opposite sex of comparable age had to do the same activity try to predict how many times they would successfully hit the target out of 12 trials?*

    1    2    3    4    5    6    7    8    9    10    11    12

6. *How difficult do you think the task of target shooting will be?*

*Very difficult*      1    2    3    4    5    6    7      *very easy*

*Moderately difficult*

7. *Now rate how difficult the task of target shooting was?*

*Very difficult*      1    2    3    4    5    6    7      *very easy*

*Moderately difficult*

8. *In a competition with the opposite sex on target shooting who you think would score better?*

    1.*self*                    2.*opposite sex*                    3.*no opinion*

**Appendix 2: Questionnaire used for elite dart players in Experiment 1a.**

GENDER: male female AGE IN YEARS:

LEVEL OF SKILL International county superleague

1. *Do you consider target shooting? Male oriented Female oriented Neutral*

2. *Estimate how many times you will hit the target out of 12 darts.*

1 2 3 4 5 6 7 8 9 10 11 12

3. *If the opposite sex had to do the same activity estimate how many times they would successfully hit the target out of 12 darts.*

1 2 3 4 5 6 7 8 9 10 11 12

4. *How difficult do you think the task of target shooting will be?*

Very difficult 1 2 3 4 5 6 7 very easy

Moderately difficult

5. *In a competition with the opposite sex on target shooting who you think would score better?*

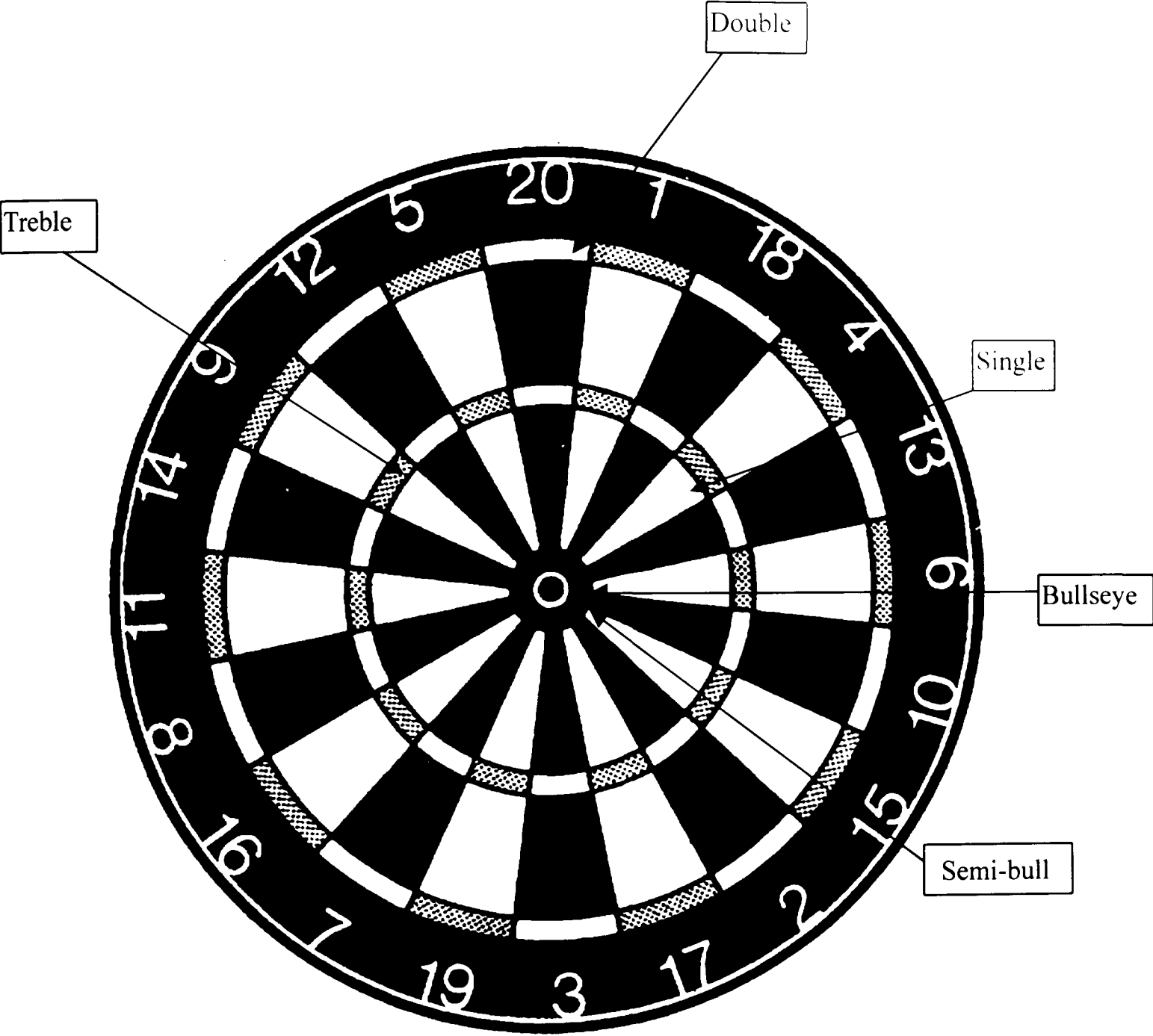
1.self 2.opposite sex 3.no opinion

6. *In a competitive match situation what do you pay most attention to?*

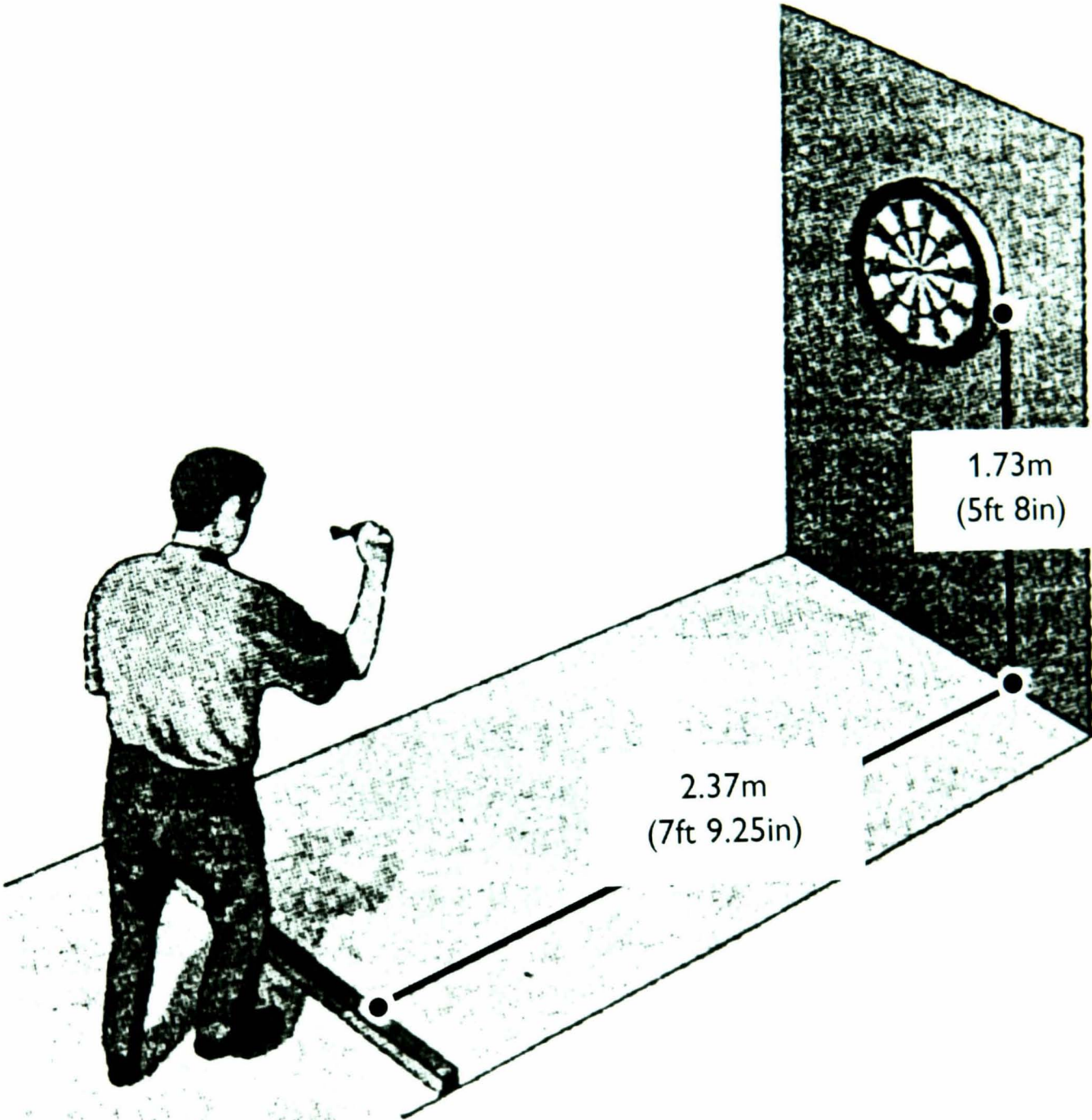
7. *In a competitive match situation what do you find most distracting?*



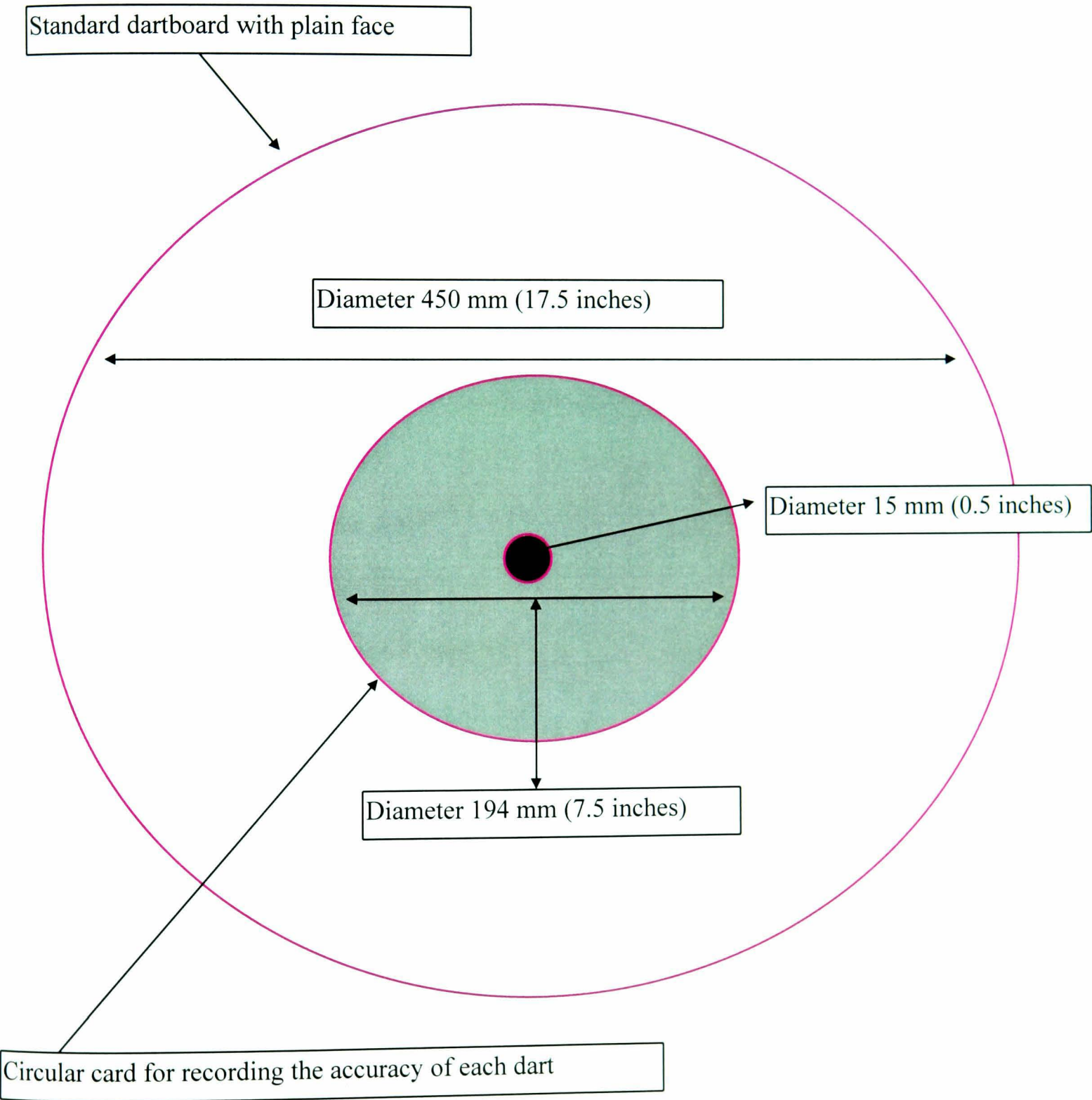
Appendix 3: Standard championship dartboard.



**Appendix 4: Standard throwing dimensions for championship dart matches.**



Appendix 5: Apparatus used in Experiments 1, 1a and 2.



**Appendix 6: Semi-structured interview schedule.**

**Introduction**

In this interview, we would like to get some detailed information about your dart playing development. I will ask you some general questions followed by more focused questions about your dart playing development, practice methods, competition experience and experience with memorisation. It is most important that you try to recall the facts as precisely as possible. Please mention if you feel uncertain about any of your memories. I have to ask everyone the same questions, and therefore I will be reading most questions to you.

Are you ready?

**General**

To begin, I would like you to answer some general questions.

**How old are you right now?**

**Which hand do you throw with?**

**How long have you played darts?**

**Where do you live (town and County)?**

**What is your current dart playing status?**

- |                     |                      |
|---------------------|----------------------|
| <b>Professional</b> | <b>International</b> |
| <b>County ‘A’</b>   | <b>County ‘B’</b>    |
| <b>Other</b>        |                      |

**What weight are your darts?**

**Are there any activities that you engaged in prior to starting with darts that you think were beneficial or perhaps created problems?**

## **Darts Biography**

I know you have extensive experience and training in darts and I am now going to focus on this in more detail.

**Do you recall your first contact with darts?**

**When and where was that?**

**What age were you at this time?**

**When did you first throw darts?**

**What age were you at this time?**

**How old were you when you played darts regularly?**

**What age did darts become a priority in your life?**

**Can you recall any of the factors that led you to start regular involvement in darts?**

**Did you receive regular darts instruction?**

**If yes, who was your very first teacher?**

**Were you motivated to improve your level of performance at this time?**

**If yes, how did you do this?**

**Do you currently receive regular instruction for dart playing?**

**If yes, what did you practice in your last session?**

**During your early years was your dart playing supervised?**

**If yes, by family member/friend**

## **Specific Practice**

**Can you recall what types of things you did when you started practice by yourself?**

**Did you play entire games with yourself?**

**Did you practice on specific shots or segments of the board or anything else?**

**Have the type of activities you practice changed during your career or are they similar to when you started?**

**Are you still motivated to practice now, if so why?**

**In what way is your practice when you are alone different from playing a competition?**

**In what way is your practice when you are alone different from playing for fun with friends or training with friends?**

**Do you prefer to practice at a particular time of day?**

**Do you ever have to make specific changes to your time of practice?**

**If yes, how does this affect you?**

**Are there any changes in the duration of a typical practice session?**

**Are there any changes in your planning and the structure of what you do during a typical practice session?**

**How focused is your training on upcoming competitions and specific opponents?**

**Do you think that your performance can be improved beyond your current level?**

**If so, are you currently trying to improve your performance through practice?**

**Any particular aspects?**

**If so which ones?**

**If not why not?**

**Can you describe your most recent practice session and tell me about the things that you do frequently?**

**Looking back on your career, can you recall any aspects that you tried to improve by practice but were unsuccessful?**

**If so which ones?**

**Any specific methods of practice that you tried?**

**Looking back on your career, can you recall any aspects of your game that practice seemed to improve?**

**If so which ones?**

**Looking back on your career has anything other than practice, contributed to your current level of performance and made it better or worse than some of your competitors?**

## **General Practice**

**Has past amount of deliberate practice contributed significantly to your current level of performance?**

**Is practice immediately prior to a tournament a reliable predictor of performance?**

**Is your current practice regime satisfactory?**

**Do you get maximum benefit from your practice regime?**

**Do you have ideas on how to improve your practice?**

**Think back to the start of regular practice and try to recall the first insights that you had into its effects.**

**Are exhibition matches a beneficial form of practice?**



**Generally, how would you rate practice sessions on a scale of 0 to 10 (where 10 is high, 5 is average, and 0 is low) on each of the following?**

**Physical effort**\_\_\_\_\_

**Mental concentration**\_\_\_\_\_

**Enjoyment**\_\_\_\_\_

**Now I want you to rate your practice sessions in relation to your form in competitions:-**

**Good form in competitions**

**Physical effort**\_\_\_\_\_

**Mental concentration**\_\_\_\_\_

**Enjoyment**\_\_\_\_\_

**Bad form in competitions**

**Physical effort**\_\_\_\_\_

**Mental concentration**\_\_\_\_\_

**Enjoyment**\_\_\_\_\_

**What single factor contributes most to your expert status?**

**Try to estimate how old you will be when you reach your maximum potential in your sports career.**

**If you have already reached your maximum potential how old were you when you did this?**

**Can you tell me about other major events or variables that allowed you to reach your maximum level of performance?**

**How old will you be when you retire from open competitions?**

**The role of practice in the maintenance of performance.**

**Have you for any extended time stopped playing or practising darts?**

**If so, did you notice any effects on your performance?**

**What do think would happen if you kept on competing in darts (say one competition per week) but stopped all additional forms of practice?**

**after a month**

**after three months**

**after a year**

**What do think would happen if you stopped playing totally and then unexpectedly had to play in a tournament without any prior practice or other preparation?**

**after a month**

**after three months**

**after a year**

**Do long practice sessions help you prepare and maintain concentration for long events?**

**Performance career.**

**How old were you when you first participated in any of the following events with recorded results?**

**Competition at the local or club level**

\_\_\_\_\_ years old for first participation  
\_\_\_\_\_ have never done it  
\_\_\_\_\_ years old for first win  
\_\_\_\_\_ have never done it

**Competition at county level**

\_\_\_\_\_ years old for first participation  
\_\_\_\_\_ have never done it  
\_\_\_\_\_ years old for first win  
\_\_\_\_\_ have never done it

**Competition at national level**

\_\_\_\_\_ years old for first participation  
\_\_\_\_\_ have never done it  
\_\_\_\_\_ years old for first win  
\_\_\_\_\_ have never done it

**Competition at International level**

\_\_\_\_\_ years old when played first International match  
\_\_\_\_\_ How long had you been playing darts  
\_\_\_\_\_ years old for first participation in competition  
\_\_\_\_\_ years old for first win  
\_\_\_\_\_ have never done it

**How many Championships have you won at world level?**

**Thank you. Now I am going to ask you about memorisation.**

## **Memory and Performance problems.**

**How many dart finishes have you memorised?**

**Try to estimate the percentage of memorised versus non-memorised material.**

**Has this percentage been the same throughout your dart playing development?**

**When performing a three dart finish do you subtract the score of each dart as you throw?**

**Yes/No**

**If No, can you describe how you perform a finish?**

**Have you ever tried to improve your ability to memorise through specific exercises or training?**

**How have you done this?**

**Do you worry before or during performances about things that could happen?**

**What are the things that you can deal with and what are the things that you think you would not be able to deal with.**

**[Give example: broken equipment, missed double, going for wrong finish, scoring badly]**

**Do these examples cover all the problems you have encountered or heard about from other dart players?**

**If not, what are other problems?**

**Sometimes dart players may experience memory problems when playing in public. Has this ever happened to you?**

**What is the very first instance you can recall when you had a memory problem?**

**Can you recall a recent memory problem?**

**Is there anything in your practice that you do to prevent memory problems or the potential for those?**

**Do you ever know that a dart is accurate when it leaves your hand before reaching its target?**

**Looking back on your development, list all the aspects of your performance that you feel have been influenced by your training?**

**Are there any specific aspects that you are still trying to change and improve?**

Appendix 7: Activity chart.

	Hours per week spent engaging in each activity for each year since start of playing career								
Throwing darts with friends for fun									
Participation in competitions									
Deliberate practice (alone)									
Deliberate practice (with a training partner)									
Playing exhibition matches									
Playing local league/superleague									
Receiving Instruction									
Physical training activities, such as general aerobic conditioning, strength training									
Mental training, such as self-hypnosis, mental imagery									

Appendix 8: Graphic display of interaction for level of skill.



Appendix 9: Graphic display of interaction for playing league darts.

